Vol. 21 JANUARY, 1947 No. 1

# SURGERY

*A Monthly Journal Devoted to the Art and Science of Surgery*

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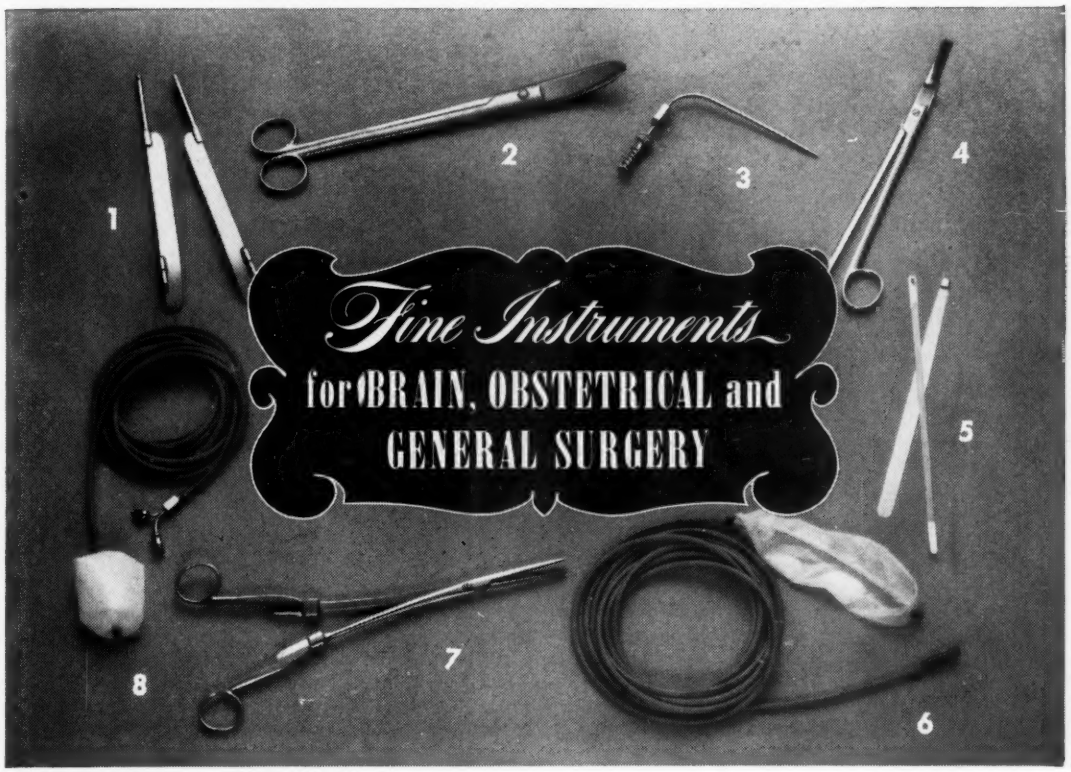


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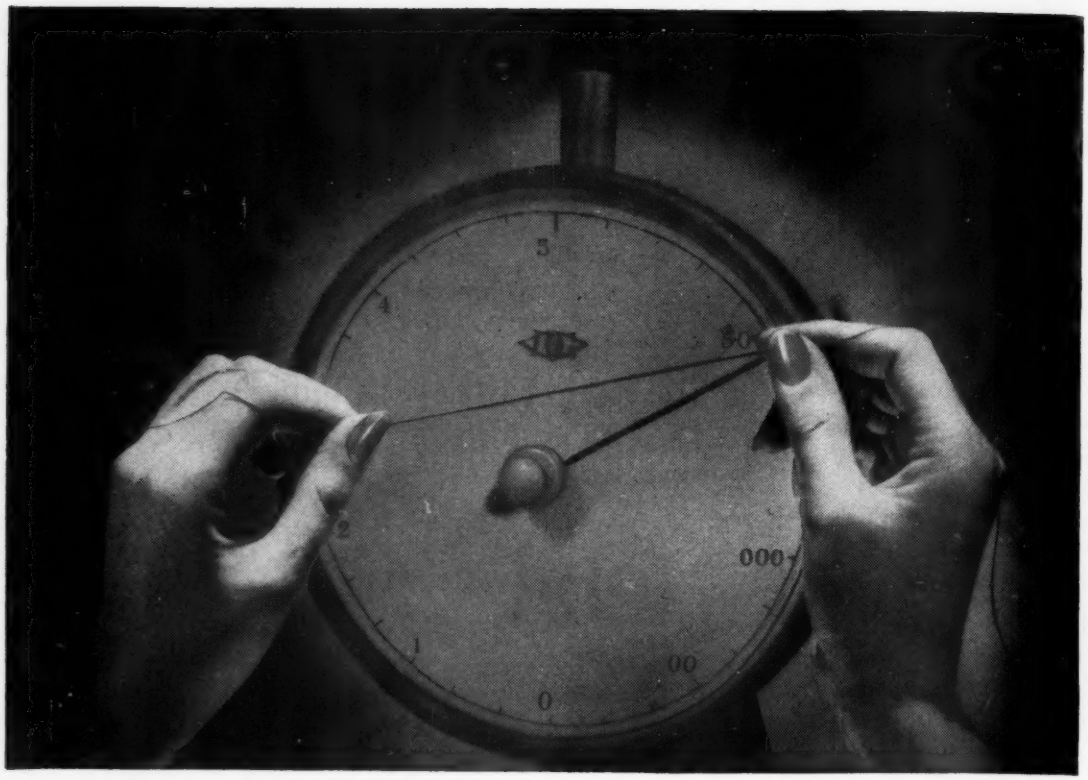


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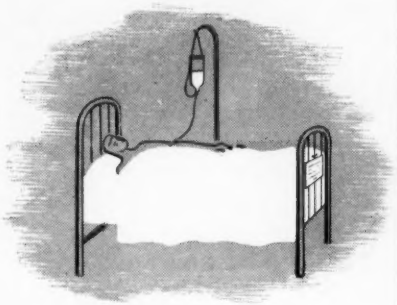

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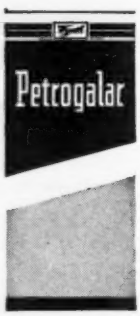


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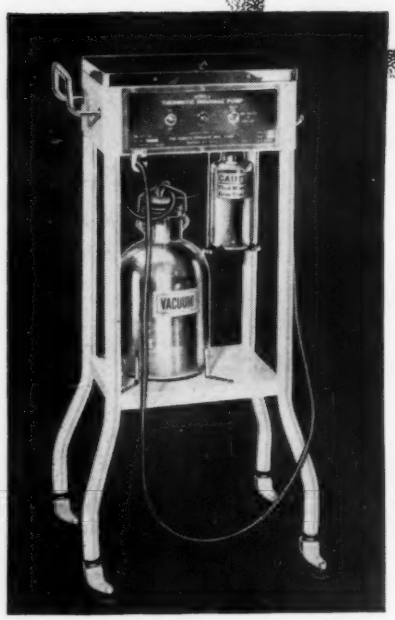


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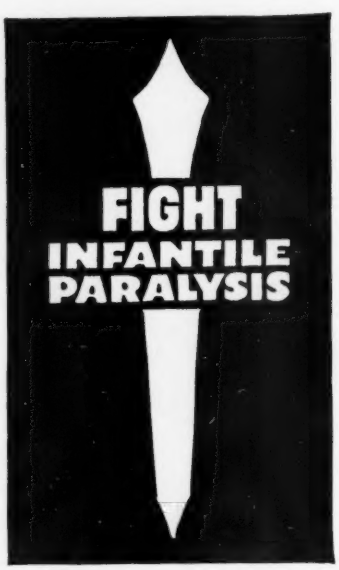


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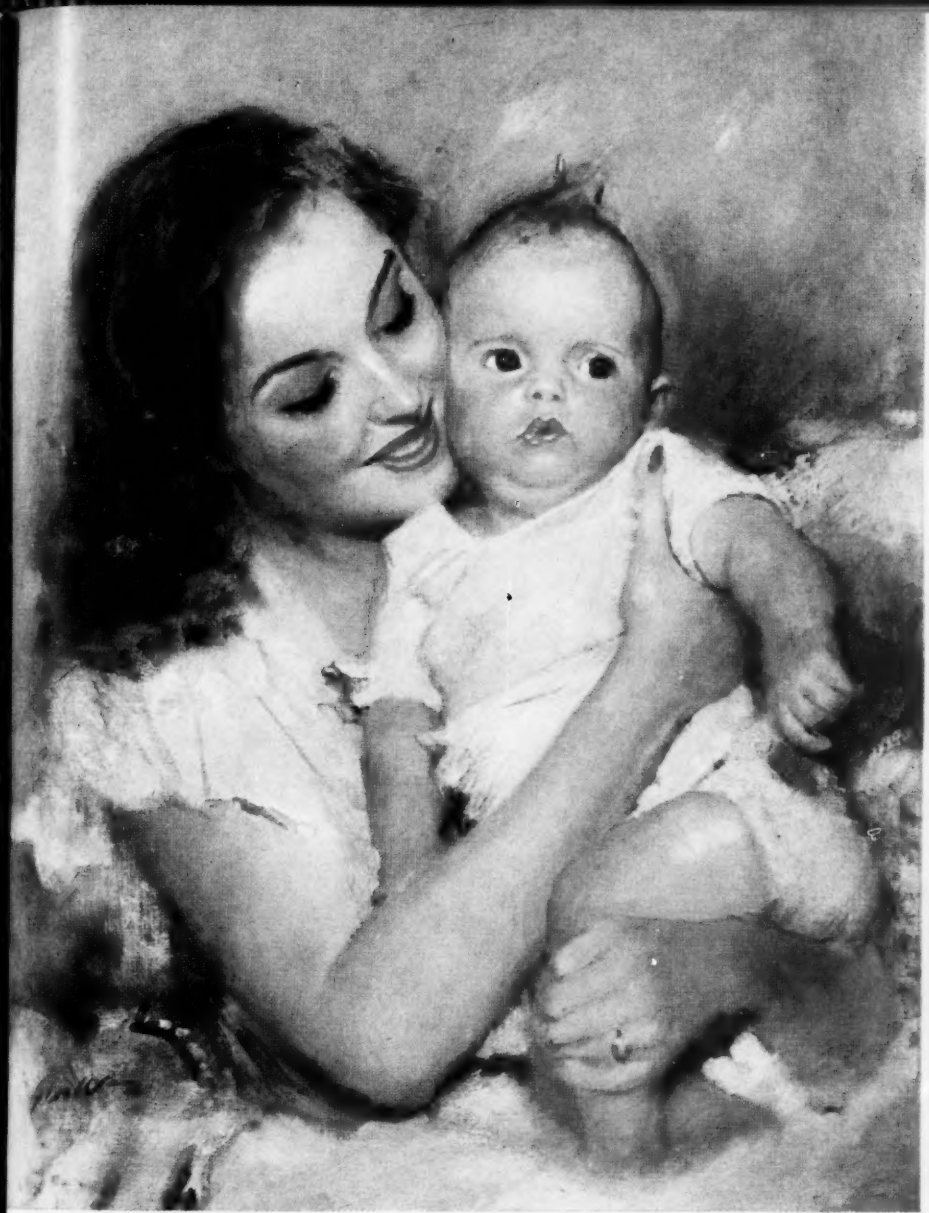

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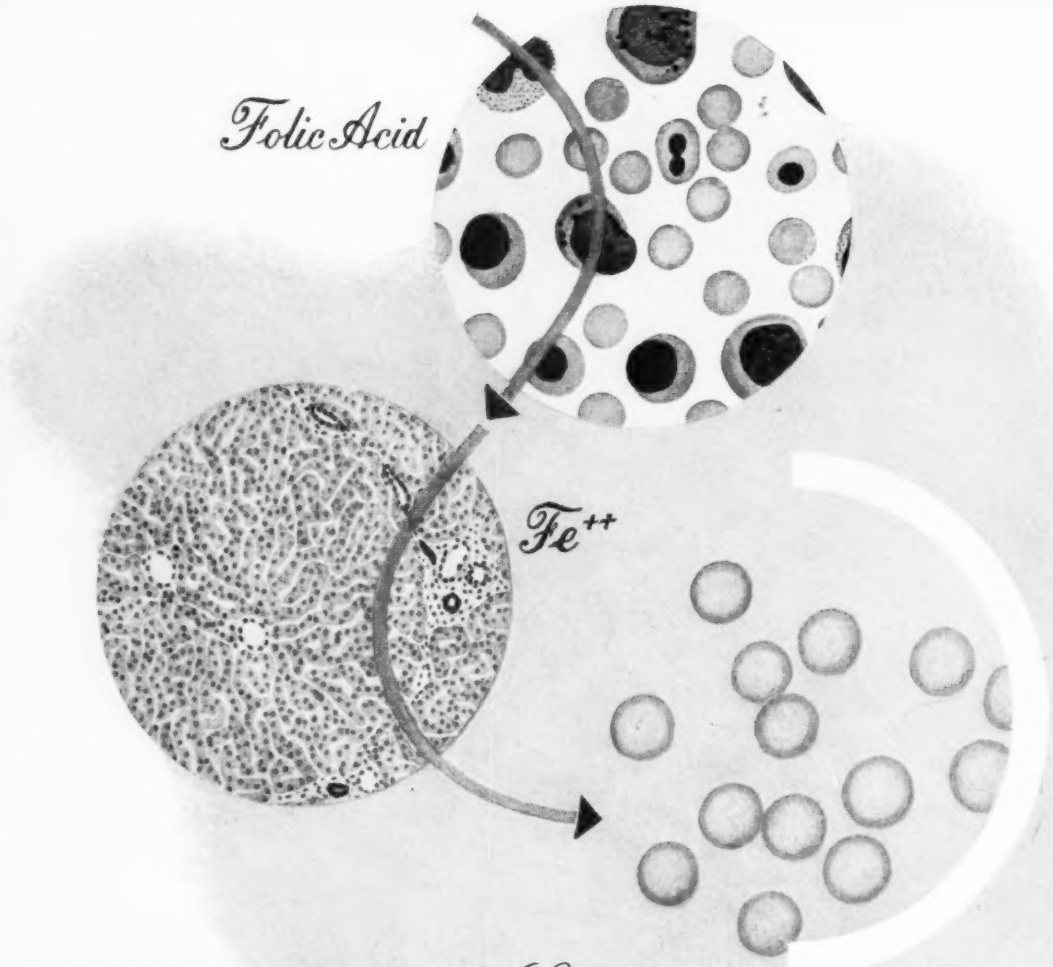


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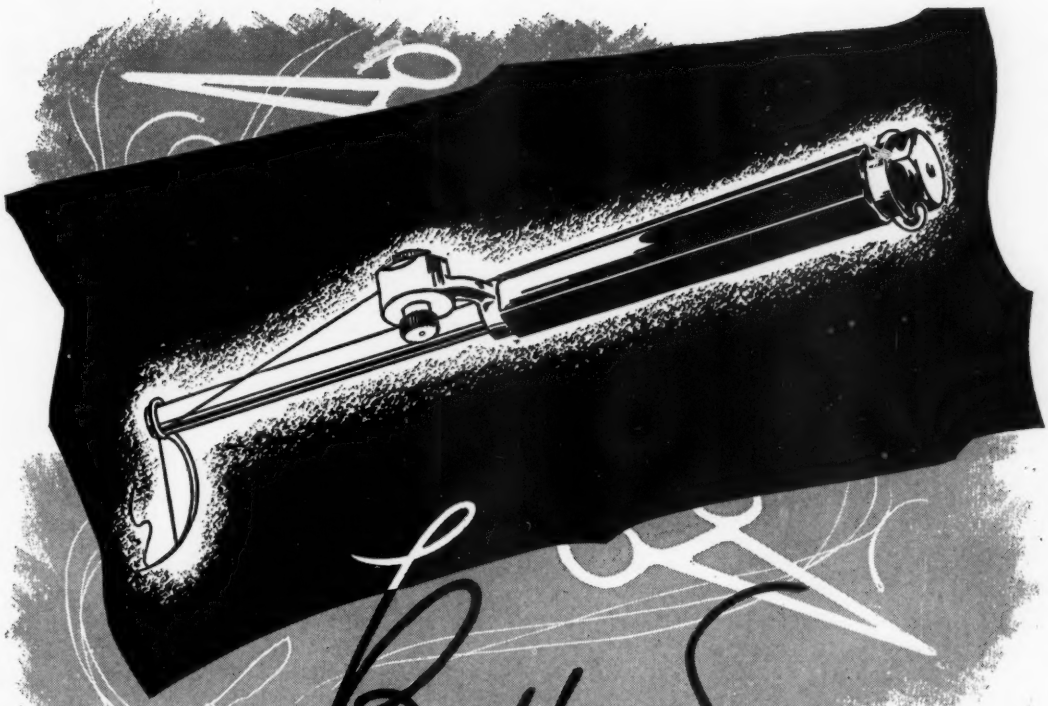

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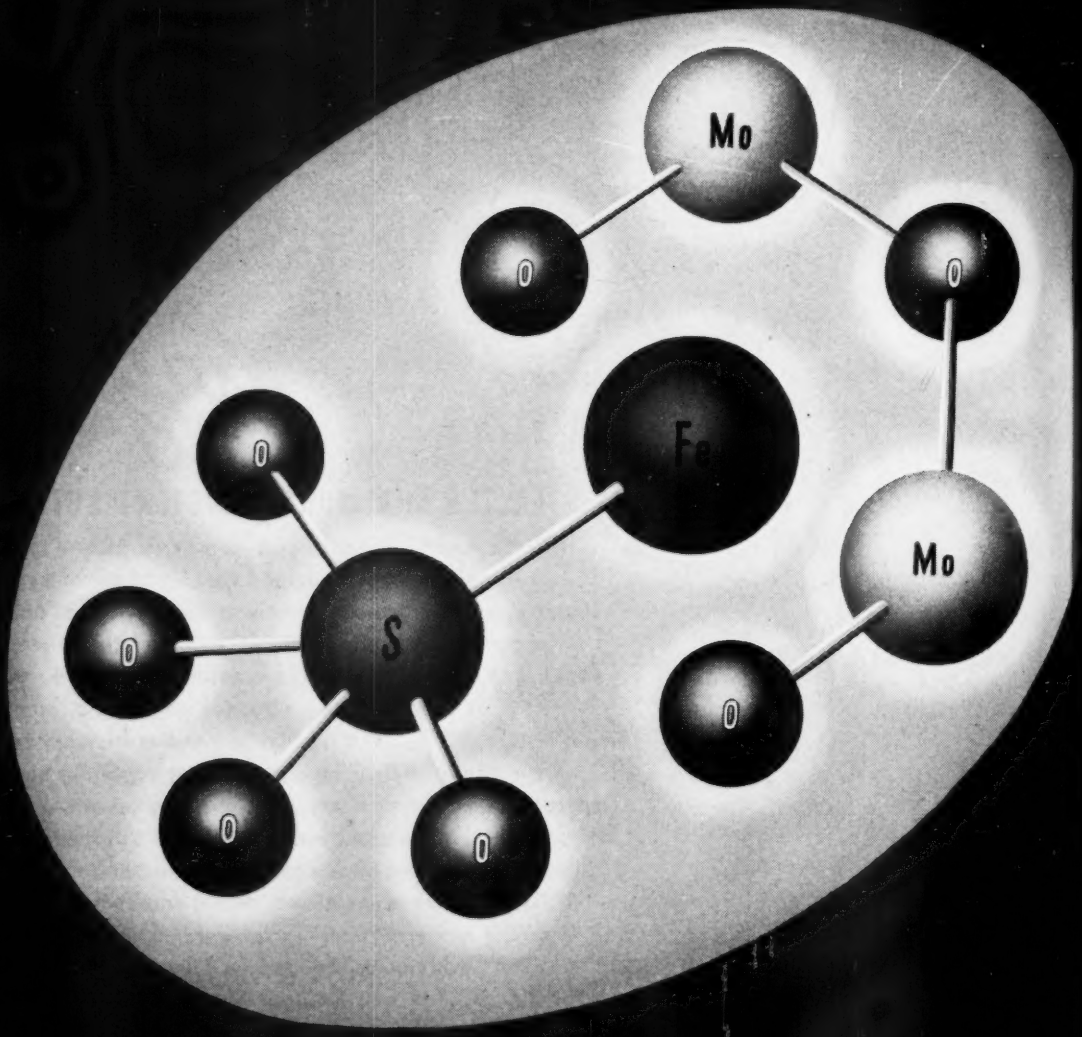


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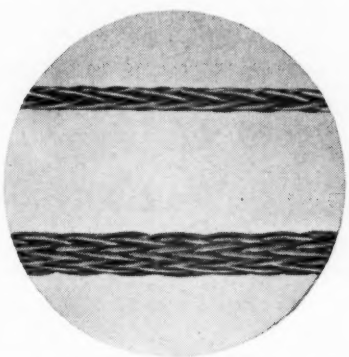

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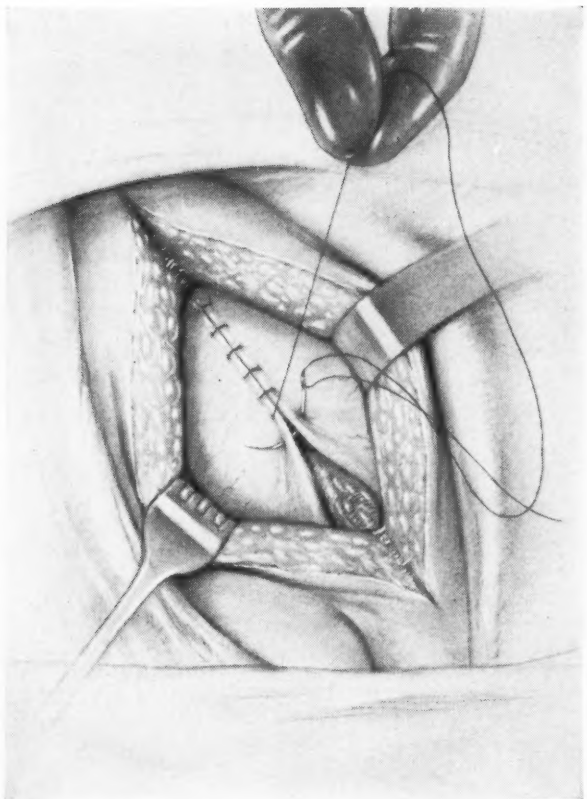

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# SURGERY

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## Original Communications

### ABDOMINAL SURGERY IN THE EVACUATION HOSPITAL

#### EXPERIENCE WITH 335 ABDOMINAL INJURIES IN THE CAMPAIGN IN NORTHERN EUROPE

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DURING a six-month period of intermittent operation in the course of the campaign in Northern Europe, 335 patients with abdominal injury were treated in an evacuation hospital. These wounded represented 3.6 per cent of the total battle casualties received during the same period. For the most part the patients were American soldiers and prisoners of war in the young adult class, although a number of civilians were treated, among whom the extremities of age were encountered.

The hospital functioned under tentage at all but one station. The operating tents, which provided ten tables, were connected with the shock and preoperative wards and with the x-ray department. These patients were operated upon by permanent and attached members of the surgical service, under the direction of one of us (C. S. W.).

It has been well established that the results obtained in abdominal surgery in World War II are far better than in previous wars. Although the operability rate has increased, the operative mortality rate has been markedly reduced. This has been brought about chiefly by more efficient and rapid transportation to the hospital; better supportive treatment with blood, plasma, and oxygen; improved surgical methods, including anesthesia; and therapy with sulfa derivatives and penicillin.

The operative mortality and results which we shall present are based upon the immediate recovery from surgery, representing usually a ten-day postoperative period, up until the time that the patient was considered to be safely evacuable. Thus, they are the results of the surgeon working in the field, in a specialized echelon of surgery.

We are aware that additional morbidity and mortality will occur from secondary operations and from late postoperative complications. These statis-

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ties, however, are not known to us at this time, but judging from the condition of our patients on evacuation, we would expect the additional mortality to be small.

### CLINICAL FINDINGS ON ADMISSION

*Classification.*—From the clinical standpoint we found that wounds involving the abdomen fell into one of three groups, depending upon the location of the wound of entrance. These were (1) the classical penetrating or perforating wounds which enter the abdomen from the front or back, which we have designated as the *abdominal* group; (2) wounds of the buttocks, perineum, and lateral aspect of the hip below the level of the greater trochanter of the femur, associated with suspected involvement of the intestinal tract or bladder, which we have called the *pelvioabdominal* group; and (3) combined injuries of the thorax and abdomen, which we have designated as the *thoracoabdominal* group.

The *abdominal* group was the largest (169 cases).

The *pelvioabdominal* group, made up of eighty-three cases, carried the lowest mortality rate, and comprised injuries not commonly seen in civil practice. They resulted largely from the fact that soldiers are frequently hit when crouching or lying prone, and sometimes are wounded by mine explosions. Commonly the injuries were limited to the extraperitoneal rectum and bladder, and consequently presented special problems in diagnosis and treatment.

The *thoracoabdominal* group also included eighty-three cases and carried a somewhat higher mortality rate than the other groups. These cases represented the most complicated problems, since both body cavities were involved, and at times major operative interference in both the chest and abdomen was required.

The proportionate number of cases in the three groups (2:1:1, respectively) reported in this series probably represents their actual incidence in this campaign, since in the evacuation hospital, functioning as it did at varying distances from the front, all of the more seriously wounded were treated without selection of cases. Furthermore, during this six-month period, casualties were received which were the result of both mobile and static warfare.

The statistics which follow apply only to the 303 patients operated upon. The thirty-two nonoperative cases are discussed in the section entitled Operability, but they have been omitted in compiling the general statistical data, since usually the exact nature of the injuries could not be determined. The condition of the patients precluded thorough examination during the short time they lived and no autopsies were performed. The omission of these cases should in no way be interpreted as an attempt to minimize their importance, however.

*Location of Wounds.*—In the abdominal group there was a fairly uniform distribution of wounds in each of the four quadrants of the abdomen and in the flanks and lumbar regions. In the pelvioabdominal group, wounds of the buttocks greatly predominated over those of the perineum and thigh. In the thoracoabdominal group, right-sided wounds outnumbered left-sided in the

ratio of four to three, presumably because left-sided wounds are more likely to be fatal on the battlefield. In addition, the wounds were more commonly lateral or posterior, due to the greater exposure of these regions in combat attitudes, and to the fact that anterior wounds are also more often quickly fatal. The missile traversed the pleural cavity before entering the abdomen four times as often as primary penetration of the abdomen with secondary involvement of the thorax. In nearly all of the thoracoabdominal cases, the wound of entrance was between the transverse plane of the nipples and that of the umbilicus. The size of the external wound was not a reliable indication of the degree of internal damage.

*Causative Missiles.*—Analysis of the type of causative agent in the patients operated upon indicated that 76 per cent of the wounds were due to shell fragments (the term being used to include fragments of artillery shells, aerial bombs, grenades, mines, and booby traps), 22 per cent to bullet wounds, and 2 per cent to blunt trauma, mostly the result of vehicle accidents.

Shell fragment wounds were most common in the thoracoabdominal group, where they were six times as frequent as bullet wounds. They were only 2.5 times as common in the pelvioabdominal group.

The missile wounds were penetrating in type in 79 per cent, perforating in 19 per cent, and both penetrating and perforating in 2 per cent. Bullets, of course, had a greater perforating tendency (three perforating to two penetrating wounds). This was most marked in the abdominal group, where five out of six bullets perforated, whereas only one out of eight shell fragments perforated the abdomen. On the other hand, only about one-third of the gunshot wounds and less than one-twentieth of shell fragment wounds in the pelvioabdominal group were perforating in type, due undoubtedly to the greater retarding effect afforded by the bony pelvis and soft tissues.

*Condition on Admission.*—The patient's condition on admission is the result of a number of factors, most important of which is shock due to trauma and hemorrhage. Other important factors include the multiplicity and severity of associated injuries; respiratory and circulatory disturbances due to concomitant wounds of the thorax; evisceration; and exhaustion, anxiety, and exposure. By evaluation of these factors, the patient's condition was described by one of the following terms: (1) good, (2) fairly good, (3) fair, and (4) poor. In most cases this grouping corresponded to the degree of shock present, that is, none, slight, moderate, and severe.

The percentage of patients in poor condition on admission varied greatly from one station to another, depending upon the tactical situation, the highest being 32 per cent and the lowest 6 per cent. The operative mortality rates for these four groups rose from 1.7 per cent for patients admitted in good condition to 50 per cent for those admitted in poor condition.

An analysis of operative cases with perforated viscera in the abdominal group is given in Table I. It will be noted that the average interval between wounding and admission was only 1.7 hours longer for patients in poor condition (where the mortality rate was 48 per cent) than that for those in good condition (where the rate was 0). Part of this increase in time lapse was accounted

TABLE I. CONDITION ON ADMISSION IN 115 PATIENTS OPERATED UPON WITH PERFORATED VISCERA IN THE ABDOMINAL GROUP

| CONDITION ON ADMISSION | AVERAGE HOURS BETWEEN WOUNDING AND ADMISSION | MODERATE OR SEVERE ASSOCIATED INJURY (PER CENT) | OPERATIVE MORTALITY RATE (PER CENT) |
|---|---|---|---|
| Good | 7.5 | 33 | 0 |
| Fairly good | 6.8 | 38 | 14 |
| Fair | 7.9 | 43 | 25 |
| Poor | 9.2 | 52 | 48 |

for by the necessity of delay in forward echelons for the treatment of severe shock. It is true that associated injuries were somewhat more frequent in patients in poor condition, but this increase also by no means paralleled the progressive increase in the operative mortality rate.

The estimation of the patient's general condition, therefore, offers the best single preoperative guide to prognosis.

*Preoperative Complications.*—The most frequent preoperative complications were those peculiar to thoracoabdominal injuries. These included open pneumothorax (25 cases), moderate to severe hemothorax (24 cases), hemoptysis (18 cases), moderate or severe intrapulmonary bleeding (11 cases), diaphragmatic herniation (7 cases), and atelectasis (2 cases).

Evisceration was the most important complication in the abdominal group (12 cases). In addition, four cases were observed in the thoracoabdominal group, and two in the pelvioabdominal group. Evisceration of the omentum only was present in seven of the eighteen cases, and then was significant primarily as an indication of abdominal penetration.

Certain other preoperative complications were also more important from the diagnostic standpoint than per se. Some of these were hematemesis (2 cases); drainage from the wound of urine (25 cases), feces (5 cases), gastric content or bile (2 cases), and hemothorax or hemoperitoneum fluid.

Hemorrhage from the wall of the chest or abdomen was of importance in relatively few cases. Morphinism was well marked in one case. Preoperative transfusion reactions were severe in three cases.

Preoperative subacute or chronic bronchitis was not infrequent among soldiers, many of whom were heavy smokers, and this fact undoubtedly had a bearing on the incidence of postoperative atelectasis and bronchopneumonia.

*Associated Injuries.*—Extra-abdominal injuries associated with abdominal wounds are an important cause of morbidity and mortality. Exclusive of minor wounds, they were present in 55 per cent of all patients operated upon in this series, and were considered to be the chief cause of death in six cases, and the secondary cause in at least twelve cases.

Associated injuries may be described as related or unrelated to the abdominal lesions. Related injuries are caused by the same missile which produced the abdominal injury, for example, fractures of the spine or pelvis. Unrelated injuries are caused by a different missile, nearly always another shell fragment.

When small flesh wounds are excluded, the associated injuries can be divided into three groups: moderate, moderately severe (for example, fractures

of the long bones, skull, pelvis, or spine), and severe (for example, transection of the spinal cord, severe intracranial injuries, and fractures of an extremity associated with vascular damage). The injuries in the patients operated upon were classified as moderate in 24 per cent, moderately severe in 20 per cent, and severe in 11 per cent. The combination of associated injuries in patients with abdominal wounds has little counterpart in civil practice, where the abdominal injury is usually the only one. Some examples of the most serious associated injuries are given here:

*Spinal cord injuries:* There were eight patients (three deaths) with involvement of one or two vertebrae from the tenth dorsal to second lumbar inclusive, of whom five had complete transection. Laminectomy was performed in only one patient.

*Intracranial injuries:* Three cases with penetrating wounds of the brain were encountered, and in each case craniotomy was deferred until the day following abdominal operation. The only death occurred five hours after an extensive bilateral frontal craniotomy in a patient who had withstood a right hemicolectomy the preceding day.

*Compound fractures of the femur:* The seriousness of this injury associated with abdominal trauma is well recognized. Gordon-Taylor[1] has described this combination as "a burden hardly to be borne by suffering humanity." In this series four of nine such patients died.

*Amputations:* Six patients in this series had major amputations of an extremity, of whom two died. In all but one case, in which completion of a partial traumatic amputation was carried out, the amputation was deferred for three to ten days after the abdominal operation.

*Intrathoracic injuries:* Seven patients, not included in the thoracoabdominal group, had some intrathoracic injury associated with sufficient abdominal signs to induce the surgeon to perform a laparotomy. In one case perforated abdominal viscera were found, and two patients had evidence of intra-abdominal blast injury. In these three cases the pulmonary injury was due to blast, but cases of blast have not been placed in the thoracoabdominal group since the causation and management are different from those of thoracoabdominal wounds. In the other four cases there were penetrating wounds of the pleural cavity but laparotomy was negative, and so by definition these cases were also excluded.

*Principles of Treatment of Associated Injuries.*—The abdominal or thoracoabdominal operation should be performed first, since it is a lifesaving procedure and cannot be postponed, nor abandoned once begun. In addition, it often improves the condition of the patient, in contrast to operations upon the extremities which tend to increase shock. Furthermore, operations on the extremities are not compelling (except in the case of partial traumatic amputation, major vessel injury, or gas bacillus infection), and one is not committed to finish the procedure if the patient's condition deteriorates. Sulfadiazine and penicillin therapy have so greatly lessened the risk of sepsis that deferment of such operations for twenty-four to forty-eight hours when necessary is justifiable.

In the case of compound fractures with emergency methods of traction, skin traction should be substituted until the deferred operation can be per-

formed. In very poor risks where it is anticipated that the patient cannot be returned to surgery for several days, the best temporary expedient is the enlargement of deep wounds to provide adequate drainage. In fact, for clean wounds of the soft tissues this treatment may suffice.

In most cases operation on the abdomen and extremities should not be carried out simultaneously, since the increased operative shock is not compensated for by the time saved. After the vital operation has been completed, the decision to perform or defer the treatment of the associated injuries can be made.

### DIAGNOSIS

The diagnosis of intra-abdominal injury was easily made in the majority of cases on the basis of the location of the wounds, especially if they were perforating in type, and on the presence of unmistakable signs and complications.

Anteroposterior and lateral roentgenograms of the abdomen were made almost routinely, and were of the greatest value in establishing the presence of abdominal penetration. In a few cases roentgenograms were not made, either because the wounds were perforating or because of the desperate condition of the patient and the obvious nature of the injuries.

The difficulties encountered in the diagnosis of perforated viscus are attested to by the number of laparotomies at which none was found (55, or 19 per cent of the major operation cases). Only twenty-three cases (8 per cent) actually represented negative explorations, however, since the others had some intra- or retroperitoneal damage or foreign body.

Although attempts were made to keep the number of negative abdominal explorations at a minimum, it was thought best because of the low morbidity and mortality of the operative procedure to carry out exploration in any doubtful cases, for the following reasons:

(1) The signs of visceral perforation, especially if due to small fragments, may be minimal. Explorations were done in several such cases, and although the surgeon felt that they would prove to be negative, intestinal perforations were found.

(2) The tendency to explain physical signs as being due to retroperitoneal hematoma alone must be guarded against, for a retroperitoneal intestinal perforation may also be present and may easily prove fatal, even though the resulting infection is drained later.

(3) The path of the missile from its entrance to exit or point of lodgment is not always straight, especially in the case of shell fragments.

(4) Even though the missile has not entered the peritoneal cavity, it may have damaged retroperitoneal structures, such as the kidney, ureter, pancreas, or major blood vessels.

(5) Indriven bone fragments, such as those from the ilium, may have perforated a viscus and yet not be visible in the roentgenograms.

(6) Missiles with high velocity may cause severe damage at distances of several inches from the actual tract by reason of the concussion wave imparted

to the tissues.[2] For example, in our series the kidney was contused or lacerated in three patients without having been struck by the missile.

(7) Finally, it is frequently impossible to say definitely from the roentgenograms whether or not a foreign body is intraperitoneal, especially when it has entered the posterior abdominal wall.

Special aspects of diagnosis in the three groups of cases are discussed here.

*Abdominal Group.*—While the classical signs of peritoneal irritation were usually present in cases with perforation of the gastrointestinal tract, the signs were sometimes equivocal when there was little or no bleeding or leakage of gastrointestinal content. On the other hand, these signs may be present when a foreign body or bone fragment is lodged in contact with the peritoneum, or when abdominal blast injury has occurred.

The question of penetration of the abdominal cavity may sometimes be decided by exploration of the wound tract. However, the latter is often lost in the deep muscular layers of the flank and lumbar regions, and one may still be unable to determine whether penetration has occurred.

*Pelvioabdominal Group.*—The first principle in the management of these cases is to assume that all wounds of the buttocks and perineum involve the intestinal or genitourinary tracts until proved otherwise. This means that all these patients must have roentgenograms of the abdomen and pelvis, unless the position of a wound of exit makes it obvious that no pelvic structures could have been injured.

It is especially important during the physical examination to search carefully for wounds of the buttocks and perineum, since they may be easily overlooked (especially in patients with a Thomas splint), and since signs of penetration of the abdomen are often absent.

Blood found on rectal examination is diagnostic of rectal perforation except in rare cases of abdominal blast injury. Unless the perforation is felt, sigmoidoscopy should be performed in all cases, even if there is no blood on the examining finger, since the presence of extraperitoneal perforation cannot be determined at laparotomy. All patients should be catheterized before operation whether they can void or not, and whether or not hematuria is present.

*Thoracoabdominal Group.*—The possibility of concomitant injury to the abdomen in patients with a thoracic wound should always be borne in mind, particularly if the wound of entrance is at or below the plane of the nipples. The physical signs of abdominal involvement in such cases are unreliable, since abdominal distention, rigidity, and tenderness frequently accompany wounds of the lower thorax, especially if they are associated with rib fractures. The crux of the diagnosis is the roentgenographic location of all missiles with a reconstruction of their course, and therefore in all wounds of the lower thorax or upper abdomen, anteroposterior and lateral roentgenograms of both chest and abdomen must be obtained.

## OPERABILITY

Of the 335 patients with abdominal injury, 77 died, a total mortality rate of 23.0 per cent. Five did not require operation and were treated expectantly.

Three hundred and three of the 330 remaining patients were operated upon, an operability rate of 91.8 per cent. The rate was lowest in the thoracoabdominal group (87.5 per cent) and highest in the pelvioabdominal group (96.4 per cent).

Of the 32 patients not operated upon, 27 died, two-thirds of them within twelve hours of admission, usually of shock which did not respond to supportive treatment. Six of these patients had severe associated injuries which of themselves contributed to the fatal outcome.

Of the twenty-seven nonoperative deaths, one occurred on the eighth day due to peritonitis from an unrecognized perforation of the sigmoid in a patient with a compound fracture of the femur. Another patient with a transection of the spinal cord, hematuria, and severe retroperitoneal hematoma, died on the seventh day after admission. The remaining twenty-five patients represent that important group in which a decision against operation was made on the basis of their extremely poor condition and inability to withstand operative interference in spite of vigorous supportive therapy.

Except in cases where operation would certainly prove fatal, every attempt was made to operate upon desperately wounded patients if it was thought that further shock therapy could do no more to improve their condition. The arrest of hemorrhage at operation may offer them their only chance of survival. Eleven patients died on the operating table during surgery or immediately afterward in the course of such procedures, but several others with an almost equally bad outlook survived. It is almost a truism that the surgeon should be concerned with the over-all mortality rate, rather than with the operative mortality rate alone.

In five patients no operation was thought to be indicated. One woman, a civilian, wounded four days before admission had an intraperitoneal foreign body and minimal signs of peritoneal irritation. Another patient with a laceration of the kidney and retroperitoneal hematoma due to blunt injury was also cared for expectantly. In the thoracoabdominal group, there were three patients with shell fragment wounds of the right lung and liver likewise treated conservatively.

### PREOPERATIVE TREATMENT

Patients with signs of shock were treated in a shock ward adjacent to the operating room. Oxygen therapy and infusions of blood and plasma were begun at once when indicated.

The refrigerated type O blood used was either whole blood or blood mixed with an equal volume of Alsever's solution. The former was preferred for patients in poor condition where it was anticipated that 1,500 c.c. of blood or more would be needed. There was a real danger of overloading the vascular system and precipitating pulmonary edema in such cases by the administration of even moderate amounts of blood when it was mixed with fluid. This was especially true in thoracoabdominal cases with much hemothorax or lung damage. Concentrated plasma was used in both prevention and treatment of such pulmonary edema with good results.

The amount of blood given depended upon the estimated blood loss, the patient's response to therapy, and the hematocrit reading. The question of the presence or absence of continuing intra-abdominal bleeding had to be decided quickly on the basis of the clinical findings, rather than upon serial hematocrit studies over a period of time.

Many casualties had received plasma, and a few received blood transfusions as well, at forward medical units. In the hospital, 55 per cent of the patients were given transfusions before or during surgery. The average amount of blood given corresponded with the degree of shock as follows: for patients in good condition, 750 c.c.; in fairly good condition, 950 c.c.; fair condition, 1,400 c.c.; and poor condition, 2,250 c.c. In addition, many of these patients received one to six units of plasma. Dextrose or saline infusions were given to a few patients who were in good condition.

Oxygen therapy by nasal catheter was given an increasingly wide application as its value for patients in shock became more and more appreciated.

Gastric suction was instituted in patients with abdominal distention and in those who showed gastric dilatation in the roentgenograms.

Penicillin therapy was given routinely on admission with a dose of 20,000 units intravenously and 20,000 units intramuscularly. The latter was repeated every four hours, except in pelvioabdominal cases, where it was given every two hours. Sulfadiazine was not administered orally to patients suspected of having penetrating wounds of the abdomen, nor was it our policy to give the drug intravenously before operation.

Aspiration of a hemopneumothorax large enough to cause dyspnea was carried out in seven of the thoracoabdominal cases.

When possible, operation was delayed until the systolic blood pressure had reached a minimum of 100 mm. of mercury and the pulse rate was less than 120 beats per minute. Some patients, however, obviously needed an immediate operation for the arrest of hemorrhage and were operated upon while in shock.

## TIME LAG

The interval between wounding and admission varied with the proximity of the hospital to the front and with the condition of the patient, for example, whether or not he had been detained in advanced medical installations for shock therapy. This interval averaged 8.4 hours, and was shortest in the thoracoabdominal cases (6.2 hours) and longest in the pelvioabdominal cases (8.9 hours).

The interval between admission and surgery could be controlled to a large extent by the surgeon, although occasionally the large number of other urgent cases on the operating schedule necessitated delay beyond the optimum time. The average of this "hospital time" for the operative cases was 8.5 hours. It was longest in the thoracoabdominal patients (11.4 hours), in whom perforated hollow viscera were less frequent, and in whom operation could more safely be delayed. It was shortest in the abdominal group (7.3 hours).

The total time lag between wounding and surgery therefore averaged 16.9 hours, which was about equally divided between transportation to the hospital

and time spent in the hospital. (This is only one hour shorter than that reported by Rohlf and Snyder in the Tunisian Campaign.[3]) The averages for the three groups were: abdominal, 15.7 hours; thoracoabdominal, 17.6 hours; pelvioabdominal, 18.6 hours.

We did not follow a policy of designating some definite time lag as an interval after which we would not perform laparotomy: several patients were operated upon over forty-eight hours after being wounded. The decision must be made on the ability of the patient to withstand operation, the nature of the injuries, and the degree of peritonitis present.

In the past, great emphasis has been placed on the importance of shortening the interval between wounding and surgery. It was felt that as little time as possible should be spent in supportive treatment since every hour was important. During World War II, however, the idea gained ground that supportive therapy must be fully adequate, and especially that lost blood must be replaced by blood. Two or three additional hours spent in allowing the patient to stabilize more than compensate for the added risk of peritonitis, which with chemotherapy is no longer as great a hazard as formerly.

The operative mortality rate does not rise significantly for patients wounded six, twelve, and eighteen hours. In our series the operative mortality rates for these intervals were: six hours, 13 per cent; twelve hours, 13 per cent; eighteen hours, 16 per cent. Furthermore, Ogilvie[4] reported a higher rate for those wounded under twelve hours than for those wounded over twelve hours. This might give the surgeon the impression that the time lag had lost most of its time-honored importance. However, improved shock therapy and prompt evacuation have permitted many seriously wounded casualties to live to reach the hospital and to be operated upon a few hours after being wounded. These poor-risk patients, who in World War I would have died en route, swell the operative mortality rates in the six-hour and twelve-hour groups to approach that of the eighteen-hour group.

## OPERATIVE MANAGEMENT

Three hundred and three of the 335 patients in this series were operated upon. Data on these cases are presented in Table II.

Injury to one or more viscera was found in 235 of the 290 cases in which major operation was performed. Exploration of the abdominal cavity was negative in twenty-three cases. In thirty-two others, while there was no visceral perforation, there were other intra-abdominal injuries varying in severity from large retroperitoneal hematomas and lacerations of the mesentery to minor serosal tears and organ contusions. In some, a foreign body had entered or traversed the peritoneal cavity without causing any appreciable damage.

Operations classified as minor procedures were carried out in thirteen patients, all of whom had perforated viscera, except one patient in the thoracoabdominal group in whom only the lateral attachment of the diaphragm had been torn. Injury to the liver in six cases, to the kidney in two, and to the spleen in one case was not severe enough to warrant exploration, and wound débridement sufficed. In two other patients, one of whom died, drainage of

TABLE II. DATA ON 303 PATIENTS OPERATED UPON

| OPERATION | ABDOMINAL | | | PELVIO-ABDOMINAL | | | THORACO-ABDOMINAL | | | TOTALS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NUMBER | DIED | PER CENT DIED | DIED | NUMBER | PER CENT DIED | NUMBER | DIED | PER CENT DIED | NUMBER | DIED | PER CENT DIED |
| Total of major operations | 147 | 26 | 17.7 | 80 | 11 | 13.8 | 63 | 12 | 19.0 | 290 | 49 | 16.9 |
| (1) Perforated viscus | 109 | 23 | 21.1 | 67 | 11 | 16.4 | 59 | 11 | 18.6 | 235 | 45 | 19.1 |
| (2) No perforated viscus, other intra-abdominal injury present | 20 | 3 | 15.0 | 8 | 0 | 0.0 | 4 | 1 | 25.0 | 32 | 4 | 12.5 |
| (3) Negative laparotomy | 18 | 0 | 0.0 | 5 | 0 | 0.0 | 0 | 0 | 0.0 | 23 | 0 | 0.0 |
| Total of minor operations | 6 | 1 | 16.7 | 0 | 0 | 0.0 | 7 | 0 | 0.0 | 13 | 1 | 7.7 |
| (1) Perforated viscus | 6 | 1 | 16.7 | 0 | 0 | 0.0 | 6 | 0 | 0.0 | 12 | 1 | 8.3 |
| (2) No perforated viscus | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 1 | 0 | 0.0 | 1 | 0 | 0.0 |
| Totals | 153 | 27 | 17.6 | 80 | 11 | 13.8 | 70 | 12 | 17.1 | 303 | 50 | 16.5 |
| Total cases with perforated viscus | 115 | 24 | 20.9 | 67 | 11 | 16.4 | 65 | 11 | 17.0 | 247 | 46 | 18.6 |
| Total cases with no perforated viscus | 38 | 3 | 7.9 | 13 | 0 | 0.0 | 5 | 1 | 20.0 | 56 | 4 | 7.1 |

peritoneal abscesses resulting from intestinal perforation was performed. In the thirteenth case, a small perforation of the stomach or jejunum, at first unsuspected, was successfully treated conservatively.

The operative mortality rate in the 303 patients operated upon was 16.5 per cent. The rate for major procedures was 16.9 per cent, and for minor operations 7.7 per cent. Operations on patients with perforated viscera carried a mortality rate of 18.6 per cent. When there was no perforated viscus the rate was 7.1 per cent.

*Abdominal Group.*—The incision to be made is largely determined by the site of involvement. In general, upper or lower rectus muscle-splitting incisions were employed. These permitted adequate exploration and exteriorization of injured portions of the right or left colon through separate laterally placed incisions. Exteriorization of the large intestine through the laparotomy incision should be avoided whenever possible to lessen the incidence of wound sepsis and dehiscence. A very useful incision for exploration of the colon and small intestine is a low midline incision, which may be extended above the umbilicus. Transverse incisions for exploration of the upper abdomen and flank incisions were rarely used. When injury to the kidney alone was present the classical lumbar incision was made.

The usual steps in complete exploration of the abdomen were followed. In poor-risk cases, when the path or location of the missile is definitely known, exploration of remote portions of the gastrointestinal tract need not be carried

out. This saves time and reduces operative shock and further dissemination of spillage in the peritoneal cavity.

Drainage of the peritoneal cavity was not employed except in cases with intraperitoneal perforation of the rectum when considerable fecal contamination had occurred, and in most cases with lacerations of the liver. In the majority of cases with perforation of a hollow viscus, a mixture of 5 to 10 Gm. of sulfanilamide powder with penicillin was introduced into the abdomen.

The wound was usually closed in layers with chromic catgut along with silk stay sutures. In a number of cases through-and-through stay sutures alone were employed. Débridement of the wounds of entrance and exit was usually done after closure of the laparotomy incision, and in patients in poor condition without large wounds, it either was performed cursorily or was dispensed with.

Of the 153 patients operated upon in the abdominal group,. twenty-seven died, an operative mortality rate of 17.6 per cent. The rate was higher (20.9 per cent) in cases with perforated viscera.

*Pelvioabdominal Group.*—In nearly all cases a low midline incision was made, since it allowed adequate exploration and repair of the intraperitoneal structures usually involved. Even when it seems likely that injury to the rectum or bladder is extraperitoneal, exploration preliminary to sigmoid colostomy is indicated in order to locate and repair any intraperitoneal perforations, such as might occur from bone fragments, and to determine the presence of a retroperitoneal hematoma which in itself was considered to be an indication for colostomy. Furthermore, intraperitoneal perforations of the bladder or injury to the ureters may exist without exhibiting hematuria.

In nearly all cases, sigmoid colostomy through a left McBurney incision is indicated. When the bladder or urethra is injured, suprapubic cystostomy should be performed after closure of the peritoneum.

In patients with wounds of the extraperitoneal rectum, drainage of the presacral space is necessary as well as wound débridement. These should be deferred until the end of the abdominal operation, since if the patient's condition is then poor they may be postponed for twenty-four to forty-eight hours. Turning the patient for these procedures often results in a fall of blood pressure of from 10 to 30 points. To avoid this, presacral drainage may be performed with the patient in lithotomy position if immediate drainage seems necessary, although this position does not give access to the buttock wound.

Presacral drainage was usually effected by an incision lateral to the coccyx, often with coccygectomy, after which Penrose drains were inserted into the presacral space. Drainage of this space through the buttock wound was not considered desirable.

There were eighty patients operated upon in the pelvioabdominal group, of whom eleven died, an operative mortality rate of 13.8 per cent. The rate for patients known or presumed to have a perforated viscus was 16.4 per cent. None of the thirteen patients without visceral perforations died.

*Thoracoabdominal Group.*—The most important aspect of the surgical management of this group is the choice of operation, which depends almost entirely

upon what organs have been injured and to what extent. The decision to operate through the chest, abdomen, or both should be based upon definite indications rather than upon personal choice.

*Thoracotomy with transdiaphragmatic operation:* The decision to perform thoracotomy with transdiaphragmatic operation (thirty cases) should have as its first requisite the presence of sufficient thoracic involvement to warrant thoracotomy, irrespective of the type and extent of abdominal involvement. The usual indications for thoracotomy are (1) large sucking wounds of the chest, (2) severe intrathoracic bleeding, (3) diaphragmatic herniation, (4) mediastinal injury, and (5) the presence of large retained foreign bodies. Fortunately, the three organs most commonly involved in this group (stomach, spleen, and liver) are accessible to transdiaphragmatic exploration and repair, and in fact are more easily operated upon through the chest than by celiotomy.

In nearly all cases, a low posterolateral or anterolateral thoracotomy incision was made to include the wound of entrance, which was excised. Elective incisions were avoided. Resection of fractured ribs was performed in twenty-one cases. Evacuation of the hemothorax, removal of foreign bodies, suture of the lung, and enlargement of the wound of the diaphragm were carried out when necessary. After suture of the diaphragm the chest wall was closed, including the skin, and closed intercostal catheter drainage of the pleural cavity was always provided.

*Thoracotomy with transdiaphragmatic operation combined with laparotomy:* Thoracotomy with transdiaphragmatic operation combined with laparotomy (twelve cases) is indicated when the undersurface of the liver is involved, when perforation of the small or large intestine is present, or when the surgeon is in doubt that the exploration of the abdomen through the diaphragm has been adequate. Fortunately, the intestine was involved in only eight cases in the thoracoabdominal group. Thoracotomy and laparotomy through separate incisions were necessary in only five cases, and then the operation calculated to do the patient the most good (that is, usually thoracotomy) was done first. In seven patients exploration of both body cavities was carried out through the same incision in the flank or upper abdomen.

*Laparotomy alone:* Laparotomy alone, with débridement of the chest wound and thoracentesis or closed intercostal drainage, was carried out in eighteen patients in whom thoracic involvement, while appreciable, did not require thoracotomy.

*Exploration of the kidney and minor procedures:* Exploration of kidney and minor procedures, such as débridement and chest aspiration, were performed in the other ten cases where no indication for either laparotomy or thoracotomy existed.

Twelve of the seventy patients operated upon in the thoracoabdominal group died, an operative mortality rate of 17.1 per cent. Of the forty-two patients subjected to thoracotomy and thoracotomy combined with direct laparotomy, ten died (24 per cent).

TABLE III. ORGAN INVOLVEMENT IN 247 PATIENTS WITH PERFORATED VISCERA

| | ABDOMINAL | | PELVIO-ABDOMINAL | | THORACO-ABDOMINAL | | TOTAL | | | INCIDENCE OF INVOLVEMENT IN PATIENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | NUMBER | NUMBER DIED | NUMBER | NUMBER DIED | NUMBER | NUMBER DIED | NUMBER | NUMBER DIED | PER CENT DIED | |
| Stomach | | | | | | | | | | |
| Alone | 5 | 1 | 0 | 0 | 5 | 2 | 10 | 3 | 30 | 4.0 |
| With others | 3 | 0 | 0 | 0 | 10 | 3 | 13 | 3 | 23 | 5.3 |
| Total | 8 | 1 | 0 | 0 | 15 | 5 | 23 | 6 | 26 | 9.3 |
| Small intestine | | | | | | | | | | |
| Alone | 31 | 7 | 3 | 0 | 0 | 0 | 34 | 7 | 21 | 13.7 |
| With others | 29 | 11 | 7 | 1 | 5 | 1 | 41 | 13 | 32 | 16.7 |
| Total | 60 | 18 | 10 | 1 | 5 | 1 | 75 | 20 | 27 | 30.4 |
| Colon | | | | | | | | | | |
| Alone | 17 | 3 | 2 | 1 | 0 | 0 | 19 | 4 | 21 | 7.7 |
| With others | 30 | 10 | 3 | 1 | 5 | 1 | 38 | 12 | 32 | 15.4 |
| Total | 47 | 13 | 5 | 2 | 5 | 1 | 57 | 16 | 28 | 23.1 |
| Rectum | | | | | | | | | | |
| Alone | 0 | 0 | 36 | 2 | 0 | 0 | 36 | 2 | 6 | 14.6 |
| Extraperitoneal | 0 | 0 | 31 | 2 | 0 | 0 | 31 | 2 | 6 | |
| Intraperitoneal | 0 | 0 | 5 | 0 | 0 | 0 | 5 | 0 | 0 | |
| With others | 0 | 0 | 7 | 1 | 0 | 0 | 7 | 1 | 14 | 2.8 |
| Extraperitoneal | 0 | 0 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | |
| Intraperitoneal | 0 | 0 | 3 | 1 | 0 | 0 | 3 | 1 | 33 | |
| Totals | 0 | 0 | 43 | 3 | 0 | 0 | 43 | 3 | 7 | 17.4 |
| Extraperitoneal | 0 | 0 | 35 | 2 | 0 | 0 | 35 | 2 | 6 | |
| Intraperitoneal | 0 | 0 | 8 | 1 | 0 | 0 | 8 | 1 | 14 | |
| Bladder | | | | | | | | | | |
| Alone | 0 | 0 | 10 | 4 | 0 | 0 | 10 | 4 | 40 | 4.0 |
| With others | 0 | 0 | 6 | 1 | 0 | 0 | 6 | 1 | 17 | 2.4 |
| Total | 0 | 0 | 16 | 5 | 0 | 0 | 16 | 5 | 31 | 6.4 |
| Ureter total | 2 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1.2 |
| Liver | | | | | | | | | | |
| Alone | 8 | 0 | 0 | 0 | 27 | 3 | 35 | 3 | 9 | 14.2 |
| With others | 11 | 1 | 0 | 0 | 12 | 3 | 23 | 4 | 17 | 9.5 |
| Total | 19 | 1 | 0 | 0 | 39 | 6 | 58 | 7 | 12 | 23.7 |
| Spleen | | | | | | | | | | |
| Alone | 3 | 0 | 0 | 0 | 7 | 0 | 10 | 0 | 0 | 4.0 |
| With others | 2 | 0 | 0 | 0 | 8 | 3 | 10 | 3 | 30 | 4.0 |
| Total | 5 | 0 | 0 | 0 | 15 | 3 | 20 | 3 | 15 | 8.0 |
| Kidney | | | | | | | | | | |
| Alone | 9 | 1 | 0 | 0 | 5 | 0 | 14 | 1 | 7 | 5.7 |
| With others | 6 | 0 | 0 | 0 | 7 | 2 | 13 | 2 | 15 | 5.2 |
| Total | 15 | 1 | 0 | 0 | 12 | 2 | 27 | 3 | 11 | 10.9 |
| Pancreas total | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 100 | 0.4 |
| Urethra total | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 100 | 0.4 |
| Totals | 157 | | 76 | | 91 | | 324 | | | |

*Management of Injuries to Specific Organs.*—The incidence of injury to the various organs in the 247 patients with perforated viscera, and their respective operative mortality rates, is given in Table III. In this table distinction is made between involvement of each organ alone and involvement with one or more other organs. Seventy per cent of the 247 patients had only one viscus involved and the rest had injury to two or more viscera. With the probably fortuitous exceptions of the stomach and bladder, multiple organ involvement was associated with a higher operative mortality rate. The operative mortality

rate in 173 patients with perforations of one or more hollow viscus was 23.7 per cent, and that in 74 with injury to solid viscera only was 6.8 per cent.

The comparative frequency of injury to the various abdominal organs in this series compares rather closely to that published for American Expeditionary Force hospitals in World War I,[5] with one exception. Perforation of the rectum made up 13.3 per cent of all organ injuries in our cases compared with 2.4 per cent in World War I.

*Stomach:* Fifteen of the twenty-three patients with stomach injuries were in the thoracoabdominal group. In eight of these repair was accomplished by transdiaphragmatic operation and in seven by laparotomy. Exploration and repair of the stomach were easily performed through the diaphragm, and since the perforations were frequently in the cardia or fundus in this group, repair through this approach was actually easier than by laparotomy.

Gastric perforations were usually closed with a double row of continuous silk sutures. Perforations of the posterior wall of the stomach should always be searched for by mobilization of the stomach after incision of the gastrocolic omentum. Special care must be taken to examine the greater and lesser curvatures, since perforations here are likely to be overlooked. The operative mortality rate in patients with gastric perforation was 26 per cent.

*Small Intestine:* The small intestine was the most frequently injured viscus (seventy-five cases), and the one most often showing multiple perforations (one to thirty in number). The duodenum was perforated in five of these.

Repair was accomplished by suture only (forty-nine cases), and by resection and end-to-end anastomosis with suture of additional perforations when present (twenty-four cases). Ileocolostomy also was performed in two of the latter patients, who required a right hemicolectomy. Exteriorization of the small intestine was done in one critically injured patient who died on the operating table. A side-to-side enteroenterostomy was carried out in another case where suture had produced narrowing of the lumen.

Perforations of the intestine were closed transversely to the long axis with two layers of silk sutures, usually with an inner continuous locking suture and an outer continuous Lembert suture. Wounds at the mesenteric border were frequently encountered, and when small might have been easy to overlook.

Resection of from three inches to six feet of intestine with end-to-end anastomosis was carried out when the bowel was nonviable or doubtfully viable, when there was complete transection, or when there were multiple severe injuries impossible to repair satisfactorily without narrowing the lumen. There were eleven patients with evisceration of the intestine and varying degrees of strangulation, and seven of these required resection and anastomosis. When doubt exists as to the viability of a segment of bowel we are convinced that it is better to resect it than to follow the policy of suture and ensheathment with omentum. In one case in which the latter course was pursued, leakage occurred and led to peritonitis and death. Open anastomosis was performed in all cases, and was accomplished by the same suturing technique as described previously. Double resections and anastomoses were required in three patients, of whom one died.

The operative mortality rate in patients with injuries of the small intestine was 27 per cent. The rate for resection with anastomosis was 33 per cent, as compared with 22 per cent when suture of perforations only was done. However, this greater mortality rate is due rather to the greater severity of the injuries, shock, and preoperative spillage in patients requiring resection than to the procedure of the resection itself.

*Colon:* The intraperitoneal colon and rectum were perforated in sixty-five cases. Injury to the left colon (thirty-five cases) was more frequent than to the right (twenty-one cases) due to its greater length, but the distribution of wounds along the length of the colon was fairly uniform. Five different operative procedures were utilized:

(1) *Exteriorization* of the injured segment (forty-three cases) was the method of choice in nearly all injuries except those of the rectosigmoid and rectum. The bowel was mobilized when necessary and a spur was formed preliminary to exteriorization through a laterally placed incision. This technique was used with an eventual extraperitoneal closure of the colostomy in mind. More recently, formation of a spur has been unnecessary since transperitoneal closure has become the rule.

(2) *Exteriorization-resection* was performed in four cases, and we believe it to be the operation of choice for extensively injured segments of the colon. It was done three times for injuries of the right colon requiring hemicolectomy, and once for a severely damaged sigmoid.

(3) *Suture of colon with proximal colostomy* was performed in ten cases. Perforation of the intraperitoneal portion of the rectum and of the rectosigmoid, which is the prime indication for this operation, was present in eight of these cases. Transverse colon colostomy with suture of perforations of the left colon was done twice, but this procedure is not recommended for lesions of any segment of the colon which can be mobilized and exteriorized.

(4) *Closure of perforations* of the cecum with catheter cecostomy was carried out in four patients.

(5) *Suture alone* was done once (for a small perforation of the cecum) but we believe this procedure should be done rarely if ever.

In two patients with perforations both of the cecum and of another portion of the colon, cecostomy and exteriorization of the injured segment were carried out. In the remaining patient there was a perforation of the sigmoid which was not found at laparotomy. This resulted in the formation of a fecal fistula, but the patient lived.

Perforations of the extraperitoneal portions of the ascending or descending colon are best treated as though they were intraperitoneal, that is, by mobilization and exteriorization of the colon, rather than by suture and extraperitoneal drainage.

The operative mortality rate in cases with intraperitoneal perforations of the colon and rectum was 26 per cent.

*Rectum:* The eight injuries to the intraperitoneal rectum have already been discussed in the preceding paragraphs.

The extraperitoneal portion of the rectum was injured in thirty-five other patients. These injuries are listed in Table III under a separate heading because the treatment, complications, and operative mortality rate (6 per cent) differ from those associated with perforation of the rest of the colon. The most important point in the management of perforations of the extraperitoneal rectum is the avoidance of retroperitoneal sepsis by diversion of the fecal stream in every case, and by drainage of the presacral space.

*Bladder:* The sixteen cases with perforations of the bladder were all in the pelvioabdominal group. The involvement was nearly always extraperitoneal, and the structure most often injured concomitantly was the extraperitoneal rectum.

Perforations were closed with two rows of sutures, the outer one being of silk. The cystostomy tube was then inserted high in the dome of the bladder so that it was well above the pubic symphysis. Suture of perforations near the base of the bladder need not always be done if they are not readily accessible. There is usually an associated extensive hematoma of the space of Retzius, often with active hemorrhage, making exposure of the bladder more difficult. When exploratory laparotomy had been performed, as was done in all sixteen cases, suprapubic cystostomy was carried out after closure of the peritoneum.

There was one patient with a rupture of the posterior urethra secondary to a crushing injury of the pelvis who died of uremia, retroperitoneal sepsis, and pneumonia.

*Liver:* Of the fifty-eight patients with liver injury, nineteen were in the abdominal group and were, in almost all cases, operated upon through a right rectus muscle-splitting incision. When it was feasible, lacerations of the liver were sutured over free omental grafts, and this satisfactorily arrested hemorrhage. Lacerations could not be sutured in two cases, and were therefore treated by packing with petrolatum gauze. Because of the possibility of leakage of bile and resultant bile peritonitis, drains should be inserted through a stab wound in the abdominal wall or flank. As a rule, lacerations of the liver caused by shell fragments were not large compared with the fractures of the liver seen in civil practice.

The large number of injuries to the liver in patients with thoracoabdominal wounds (thirty-nine cases) is to be expected because of the size and position of the organ. For the same reason, and also since it offers a barrier to missiles perforating the diaphragm, the liver was the only organ injured in twenty-seven of these cases.

In sixteen of the thirty-nine cases, no operative repair of the liver was necessary. Of the twenty-three other cases, the injury was repaired by transdiaphragmatic operation in six, and by the latter combined with laparotomy in ten. The remaining seven patients were operated upon through the abdomen, since the thoracic injury did not require thoracotomy.

In combined thoracolaparotomy through the same incision, exploration and repair of the liver were carried out through incisions in the flank (two cases), upper quadrant of the abdomen (three cases), or through a kidney incision ex-

tended to the flank (two cases). In four of these thoracoabdominal cases lacerations were packed with petrolatum gauze.

Postoperative transdiaphragmatic biliary-pleural fistula is an important complication in these cases. In order to avoid this as far as possible, tight closure of the diaphragm with nonabsorbable sutures plus transperitoneal drainage (accomplished through a stab wound of the abdominal wall) should be used for all but small liver wounds.

*Spleen:* The spleen was injured in twenty cases, fifteen of them in the thoracoabdominal group. In nine of the latter, transdiaphragmatic splenectomy was performed, and in three the spleen was removed at laparotomy. Transthoracic splenectomy is more easily performed than splenectomy by the transabdominal route. The spleen was not removed in the three remaining cases, since the injury was minimal. Splenectomy was performed in all five cases of splenic injury in the abdominal group. The operative mortality rate in these twenty cases was 15 per cent; that for splenectomy was 18 per cent.

*Kidney:* Operative procedures upon the kidney were necessary in only sixteen of the twenty-seven patients in whom this organ was injured. In ten, suture of the kidney was performed, usually over muscle grafts, and in six, nephrectomy was carried out.

Exposure of the kidney for repair or nephrectomy was always made through a lumbar incision. When indicated, the peritoneum was opened so that other structures could be examined. In the event of intraperitoneal injury demanding operation first, the extent of the injury to the kidney was estimated transabdominally, the peritoneum closed over the wound of the kidney, and, if further operation was not done through a lumbar exposure, drainage of the perirenal space was provided through a lumbar stab wound. Injury to the kidney producing a considerable hematuria frequently requires no immediate operation, especially in the presence of more urgent abdominal surgery.

Decision to perform nephrectomy is made only when very extensive injury to the kidney or its pedicle is present. Chemotherapy and transfusions have greatly lessened the danger of postoperative renal sepsis and secondary hemorrhage which were so commonly encountered in World War I.

*Ureter:* There were three patients who sustained injuries to the ureter resulting in urinary fistula, with no postoperative deaths.

*Pancreas:* One patient in the abdominal group, with a wound of the pancreas, died postoperatively with extensive fat necrosis and chemical peritonitis.

In the foregoing discussion of injuries to specific organs, the operative mortality rates listed are those for all patients with lesions of the particular viscus, whether it was injured alone or in combination with other organs.

*Anesthesia.*—The anesthetic agent employed in nearly all major operative cases was a mixture of nitrous oxide, oxygen, and ether, usually administered through an endotracheal tube. Use of the tube provided better muscular relaxation, especially in upper abdominal operations, and better oxygenation and control of respiration, which were especially important during thoracotomy. Furthermore, at the end of operation, tracheobronchial secretions could be

aspirated, an important factor in keeping pulmonary complications at a minimum. The open circuit was preferred to the closed circuit since it provided better oxygenation.

In a few cases, general anesthesia was supplemented by abdominal wall block with procaine to provide better relaxation without the necessity of deep anesthesia. In such cases, infiltration of the peritoneum with procaine solution facilitated closure of the wound.

Minor operations were performed under local procaine infiltration. Spinal anesthesia was not employed.

Of itself, the anesthetic agent did not seem to contribute to shock. In fact some patients, especially those in the thoracoabdominal group, seemed to improve after anesthesia had been induced. However, turning the patient on his side preparatory to performing thoracotomy or débridement of wounds was often associated with a fall in blood pressure.

Patients in poor condition at the end of operation were left on the table for an hour or more whenever possible while transfusion and oxygen therapy were continued. While it is true that the mortality rate is higher in cases with a long operating time, little significance can be attached to this because of the greater extent of the injuries in such cases.

## POSTOPERATIVE MANAGEMENT

All patients with chest and abdominal wounds were treated in a special postoperative ward under the supervision of a full-time medical officer. While the importance of expert postoperative care cannot be overemphasized, space permits mention of only the salient features.

Oxygen therapy was often required for as long as three to five days, especially in thoracoabdominal cases. Gastric suction was instituted almost routinely in cases with perforated viscera, and continued until a positive fluid balance had been attained and peristalsis had resumed, that is, for an average of three to four days.

Usually 3,000 c.c. of intravenous fluids and 250 c.c. of plasma were given daily as long as indicated, and in addition about forty per cent of these patients required one or more blood transfusions.

Intramuscular penicillin therapy in doses of 20,000 units every four hours was continued in all patients for seven days or longer if they were still febrile. Most patients in the pelvioabdominal group received this dose every two hours for seventy-two hours because of the supposed danger of gas bacillus infection, which, however, developed in only one case. Sulfadiazine therapy was instituted for over one-fourth of the patients in the pelvioabdominal group for the same reason, and in any case where pulmonary complications were evident or seemed likely to occur. Routine administration of sulfadiazine was not carried out.

The usual precautions for the prevention of atelectasis were taken. In patients with closed intercostal catheter drainage, the catheter was kept patent until its removal, usually forty-eight hours postoperatively, and 40,000 units of penicillin in saline solution were then injected intrapleurally. In those with

bile in the pleural fluid or gross contamination of the pleural cavity, drainage was continued for three days or longer. Thoracentesis was often necessary one or more times to remove reaccumulations of serosanguineous fluid.

Colostomy openings were made in exteriorized segments of bowel twenty-four to forty-eight hours postoperatively and were enlarged the next day. The colostomy usually began to function by the fourth or fifth day.

In general our policy was to hold post-thoracotomy patients for at least seven days and post-laparotomy patients for ten days or longer. It was, therefore, possible to keep patients until they were in good condition and could be safely evacuated.

### POSTOPERATIVE COMPLICATIONS

Shock was one of the chief causes of death and it will be discussed in the section on postoperative deaths.

The commonest abdominal complication was ileus (twenty-three cases). The clinical diagnosis of some important degree of peritonitis was made in fifteen cases, two of which were due to bile in the peritoneal cavity. Definite retroperitoneal sepsis was present in eight cases in the pelvioabdominal group.

Other abdominal complications included: gastric fistula (1 case), duodenal fistula (2), jejunal fistula (1), fecal fistula (5), urinary fistula (8), partial wound dehiscence (2), wound sepsis about the colostomy (6), gangrene of exteriorized colon (1), prolapse of small intestine through the colostomy wound (1), and considerable sepsis of the wound of entrance in the buttock (4).

Infection of the operative wound of moderate or severe degree was present in eleven patients (4 per cent of major operations).

Pulmonary complications were frequent and included thirty cases of postoperative atelectasis, frequently concomitant with bronchopneumonia (26 cases), bronchitis (6 cases) and lobar pneumonia (3 cases).

The other pulmonary complications were as follows: pulmonary edema (6), bile in the pleural fluid (6), biliary drainage from the chest wound (2), empyema (4), tension pneumothorax (2), bronchopleural fistula still present on evacuation (1), pulmonary hemorrhage (2), gangrene of one lobe of the lung (1), and small pulmonary abscess (1). In addition, several patients had some degree of hydropneumothorax on evacuation, and probably some cases of nonreexpanded lung and empyema became evident after they had left our hands.

Uremia occurred in five patients. It was thought to be due to reflex anuria in two of them, to urinary extravasation and retroperitoneal sepsis in two others, and to a severe transfusion reaction in the fifth case.

Transfusion reactions due to the use of stored type 0 blood were all too frequent (nineteen patients). Several had temporary oliguria due to hemoglobinuric nephrosis, along with prolonged hypotension.

Miscellaneous postoperative complications included thrombophlebitis of the iliac and femoral veins (2), prolonged paroxysmal auricular tachycardia (1), pyelitis (2), meningitis (1), toxic psychosis (3), and infection of the entrance wound in the buttock with gas-forming organisms (1).

POSTOPERATIVE DEATHS

*Abdominal Group.*—There were twenty-seven postoperative deaths in the abdominal group, the principal causes being hemorrhagic shock (8 cases), traumatic shock (6), peritonitis (8), and postoperative pulmonary complications (4). In practically all cases two or more of these factors were present, and it was often difficult to be sure which was the most important.

All of the eight patients who died of hemorrhagic shock had perforations of the intestinal tract with marked hemoperitoneum, and in four visceral injury was severe. All died within nine hours after surgery and four of them died on the operating table. The interval between wounding and surgery varied from eight to seventeen hours, and probably most of these patients were in irreversible shock on admission. Each had received from 1,000 to 4,000 c.c. of blood before and during surgery.

Death from traumatic shock due to severe associated injuries occurred in three patients, two of whom had no significant intra-abdominal damage. Shock was due to severe abdominal injuries in two other cases, and to marked blast injury of the chest and abdomen in the sixth case. All of these patients died within twenty-four hours of operation.

Of the eight patients who died with peritonitis, multiple intra-abdominal injuries were present in four, and intestinal resection and anastomosis had been performed in two of these. Three patients also developed serious pulmonary complications postoperatively. In six cases some degree of peritonitis was present at operation, the average time lag being twenty-eight hours. In one of these patients, already wounded forty-eight hours, the only operation was drainage of the peritoneal cavity. In the other two cases the time interval was only nine hours, and peritonitis was due to surgical errors. Suture of the intestine for multiple perforations was carried out in a 12-year-old girl in poor condition, when resection should have been done because of contusion of the bowel wall in the injured segment. The other patient developed a gastric fistula and peritonitis, due either to inadequate closure or to a missed perforation.

Respiratory complications were the chief cause of death in four patients. Two deaths, within six hours of operation, were believed to be due to aspiration of vomitus and pulmonary edema. Another patient died of massive pulmonary collapse, and the fourth had a severe tracheobronchitis with profuse tenacious sputum, not relieved by bronchoscopy.

Another 12-year-old girl, with a partial cord transection thirty-six hours old on admission, died of ascending meningitis due to Friedländer's bacillus eight days following laminectomy and nephrectomy.

*Pelvioabdominal Group.*—Associated injuries were severe in seven of the eleven patients in this group who died postoperatively. Fractures of the pelvis were present in five cases, gangrene of the leg in two, and thrombosis of the external iliac vein in another. In only one case, however, was traumatic shock thought to be the chief cause of death.

While there were no deaths due to peritonitis, two were due to severe retroperitoneal sepsis, resulting from a severe laceration of the extraperitoneal rectum in one case, and of the posterior urethra in the other.

Pulmonary complications were the ultimate cause of death in four cases (atelectasis in two, bilateral pneumonia in another, and a probable pulmonary embolus from a thrombosis of the iliac vein in the fourth).

Three patients died of uremia, two of whom also had pulmonary complications (pulmonary infarcts in one case and bilateral blast damage in the other).

The uremia was thought to be due to reflex anuria in a patient with thrombosis of the iliac vein, to a transfusion reaction in another, and to transfusion reaction complicated by sulfadiazine overdosage in a third.

The eleventh patient, who had a severely fractured pelvis with retroperitoneal hematoma, died on the tenth day of hemorrhage from several acute gastric ulcers.

*Thoracoabdominal Group.*—Shock was the principal cause of death in seven of the twelve postoperative deaths in this group. Three of these occurred at operation and four on the day of operation. Hemorrhagic shock was prominent in four of these patients (one of whom died of massive pulmonary hemorrhage) and traumatic shock in the other three.

Pulmonary complications were the chief cause of death in four other patients who died on the fourth, sixth, and eighth postoperative days. Three of these had empyema, one of whom had gangrene of one lobe of the lung, and another a bronchopleural fistula and bilateral bronchopneumonia.

The eleventh patient died with bile peritonitis, and uremia of undetermined origin, one week after nephrectomy.

In summary, the chief causes of death in the fifty patients who died postoperatively were as follows (the figure in parentheses indicates the number of cases in which the complication was an important secondary cause of death): hemorrhagic shock, 12 (9); traumatic shock, due predominantly to abdominal injuries, 4 (30); traumatic shock, due primarily to associated injuries, 6 (12); peritonitis, 8 (3); retroperitoneal sepsis, 2 (1); pulmonary complications, 12 (11); uremia, 4 (1); and others, 2 (2).

## SUMMARY AND CONCLUSIONS

1. The clinical findings, surgical management, and results obtained in the treatment of 335 casualties with abdominal injuries have been presented.

2. In 330 of these patients operation was indicated, but the poor condition of 27 precluded operation. Fifty of the patients operated upon also died, giving a total mortality rate for unoperated and operated cases of 23.0 per cent.

3. Three hundred three patients were operated upon, an operability rate of 91.8 per cent, and the fifty postoperative deaths represent an operative mortality rate of 16.5 per cent.

4. Associated injuries were present in 55 per cent of the cases, and were an important cause of morbidity and mortality.

5. Abdominal injuries have been classified into abdominal, pelvioabdominal, and thoracoabdominal groups, and the clinical significance of this classification has been pointed out.

6. The principal cause of death was shock, the result of hemorrhage or severe injury. The condition of the patient on admission and the extent of his injuries and blood loss were the best guides to prognosis. Infection and late deaths from peritonitis were not common and if the patient survived the first forty-eight hours after operation the chance of recovery was good.

7. The chief factors acting to increase the operability rate and to decrease the mortality rate in patients with abdominal wounds in World War II were more rapid and efficient evacuation, better supportive therapy with blood and plasma, improved anesthesia, sulfonamide and penicillin therapy, and improved surgical methods.

## REFERENCES

1. Gordon-Taylor, G.: Surg., Gynec. & Obst. **74**: 375, 1942.
2. Callender, G. R.: War Med. **3**: 337, 1943.
3. Rohlf, E. L., and Snyder, J. M.: Surg., Gynec. & Obst. **79**: 286, 1944.
4. Ogilvie, W. H.: Surg., Gynec. & Obst. **78**: 225, 1944.
5. Military Surgical Manuals, Vol. 3, Abdominal and Genito-Urinary Surgery; Philadelphia, 1942, W. B. Saunders Company

# PERFORATED GASTRODUODENAL ULCER

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## INTRODUCTION

THERE are few instances in the natural course of events when man may rescue his fellow man from certain death. One of the commonest of such instances in medical practice is in the case of an acute perforation of a gastroduodenal ulceration. The purpose of adding further to the already voluminous, although somewhat outmoded, literature on this subject, is to show that, for the first time, the certainty of saving such a patient is even greater than the certainty of his dying if untreated. Up to the present time, there are only two reports in the literature, those of Graham[1, 2] and Tilton,[3] of significant groups of treated patients with acute perforations, with the low mortality which can and should be achieved by all surgeons. These two groups are both small and include very favorable material.

The principles and method of treatment of this abdominal catastrophe which will accomplish such a low mortality are all well known but seem to fail to be properly correlated and applied at the same time and in all cases. The reported mortality rates of from 10 to 25 per cent of operated patients with acute perforations are inexcusably high and can only reflect a failure of surgeons everywhere to apply what is known in the treatment of this emergency, and to do so in every case with the expectation that almost no patient with a perforated ulcer should die if he is seen before he becomes moribund.

This report includes a series of eighty-eight consecutive patients operated for perforated gastroduodenal ulcers in this hospital in the three-year period since the first admission for this illness, together with the data on the few patients who were not operated. Thus, every patient who has ever entered this hospital with such a perforation is included. Of the operated patients there was only one death, a mortality rate of 1.1 per cent, and this one death was from extraabdominal causes. A brief comparison is made with other published statistical studies. A more detailed correlation of mortality in relation to various categories such as age or duration of symptoms is superfluous in a group of cases with so low a death rate. The breakdown of statistics is offered in our group of patients chiefly to demonstrate that the mortality risk in them is in every way comparable to other reported series. The number of operated patients is sufficiently large to be significant. There is no reason to believe that the mortality should be any greater in our next hundred patients; if we should have the ill luck to have twice the number of deaths in the next group, the over-all mortality would still be in marked contrast with the current figures. A somewhat detailed outline of our principles of treatment is in-

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cluded in order that they may be more generally adopted in an effort to reduce the mortality rate for people with perforated ulcers. It is fully recognized that there is little which in itself is new or even unusual in this treatment. Rather, it is felt that it is the correlation and utilization of all of the best principles in every instance which has resulted in a new and unusually low mortality rate. It is further emphasized that these principles are so simple and easily applied that this mortality rate should be the prevalent rather than the uncommon one.

## ANALYSIS OF MATERIAL

As has already been indicated, the principal reason for analyzing our material in regard to the various factors normally affecting mortality risks is to demonstrate that our group of patients in no way differs from other reported series in this regard. There are a few interesting additional data, particularly those relating to the incidence of this condition. Comparisons are made with DeBakey's collected series.[4-6]

*Incidence.*—Our figures in regard to the incidence of perforation of gastric and duodenal ulcers are particularly valuable, because all of our perforations come from a known aggregate of population of a known type, and because the ratio of perforations to other hospital admissions is similarly accurate in that such admissions are entirely unselected and represent all hospital admissions for the same definite group of people.

The population from which these cases are drawn consists entirely of skilled and unskilled working people in heavy industry under wartime conditions of work and housing. It is safe to say that all of the perforations occurring in this known group during the three-year period have been treated by us. It is to be noted that this group differs from a peacetime group of heavy industry workers in that there were more people in older age groups and more who were physically disqualified from military service and thus had a higher incidence of chronic illness such as peptic ulcer.

Calculated according to the number of perforations in relation to the average number of persons under our care, there were 34.08 perforations per 100,000 of population per year.

In relation to hospital admissions, excluding admissions for industrial accidents, there were five perforations per 1,000 admissions, or 0.50 per cent of all admissions were for perforated ulcer. This is much higher than is generally reported.[4, 5]

*Sex.*—There were three females in this series, or 2.93 per cent of the total. The average ratio of males to females under our care was 3.31 to 1. Thus the figure 2.93 per cent may be adjusted to 9.70 per cent of females to males suffering from perforated ulcers, correcting for the differential in the numbers of males and females from which our patients were drawn. This is considerably higher than the usual ratio reported in the modern literature; and, although the figure is too small to be of definite numerical significance, one may speculate that women may perforate ulcers more commonly if placed in similar working situations with men.

*Previous Symptoms.*—Fifty-seven, or 64.8 per cent, of these patients had a history of symptoms indicative of peptic ulcer. This is a somewhat lower figure than DeBakey[4-6] reports in his collected series (85.1 per cent) or his Charity Hospital series (75.3 per cent). In addition, a considerable number of those with positive histories had been having symptoms only a short while before their perforation. Possibly, there were more perforations of acute ulcers of short duration in our group than the average, or, more likely, there were more hyposensitive individuals in the group.

*Previous Perforations.*—Six, or 6.8 per cent, of these patients had one or more previous perforations. Cohn reported twelve reperforations in 300, a rate of 4 per cent, at the San Francisco County Hospital.[7] The rate of reperforation is no doubt increasing commensurate with the rapid increase in the incidence of perforation generally.

*Age.*—There is little doubt that age of the patient is fully as important as the preoperative interval in determining the mortality rate among the published series. This is well demonstrated by the reports of DeBakey and Odom,[6] Barber and Madden,[8] Kelly,[9] and others. Our age distribution is seen in Table I.

TABLE I. AGE DISTRIBUTION IN EIGHTY-EIGHT PATIENTS OPERATED FOR PERFORATED PEPTIC ULCER

| AGE | NUMBER PATIENTS | PER CENT PATIENTS |
|---|---|---|
| Under 20 | 0 | 0.0 |
| 20-29 | 12 | 13.6 |
| 30-39 | 23 | 26.1 |
| 40-49 | 26 | 29.5 |
| 50-59 | 19 | 21.6 |
| 60-69 | 7 | 8.0 |
| 70-79 | 1 | 1.1 |

DeBakey's collected series[4, 5] showed that 4 per cent of reported perforations occur in the first and second decade, 73.1 per cent in the third to fifth decade, and 22 per cent past the age of 50. Our patients were in a significantly older age group, over 30 per cent being 50 years old or older.

TABLE II. TABULATION OF EIGHTY-EIGHT PATIENTS OPERATED FOR PERFORATED ULCER ACCORDING TO TIME ELAPSED BETWEEN PERFORATION AND SURGERY WITH COMPARISON TO THE COLLECTED SERIES[4, 5]

| HOURS ELAPSED | OUR SERIES | | | COLLECTED SERIES | |
|---|---|---|---|---|---|
| | NUMBER PATIENTS | PER CENT PATIENTS | MORTALITY | PER CENT PATIENTS | PER CENT MORTALITY |
| 0- 6 | 34 | 38.63 | | 50.83 | 10.5 |
| 0-12 | 37 | 42.04 | | 31.02 | 21.4 |
| 12-18 | 13 | 14.77 | | 3.03 | 38.5 |
| 18-24 | 2 | 2.27 | | 1.43 | 62.4 |
| Over 24 | 2 | 2.27 | | 13.66 | 61.5 |
| All Cases | 88 | 100.00 | 1.1 | 100.00 | 22.4 |

*Preoperative Interval.*—From the data in Table II it is readily seen that our group is also more unfavorable than is the average in DeBakey's collected series in regard to time elapsed between perforation and treatment. This is particularly true of the group under six hours. It is also true, however, that we have had much fewer perforations over twenty-four hours than the average

of the collected series. Our one mortality was a 49-year-old man who had been perforated fifteen hours before surgery. As will be detailed later, he died of heart failure, so that neither age nor time had any bearing upon his death.

*Pneumoperitoneum.*—Forty-eight, or 58.5 per cent of the eighty-two patients who had films taken, demonstrated roentgenologic evidence of pneumoperitoneum preoperatively. We believe that more careful technique in keeping the patient in proper position for a longer while before taking upright and lateral films would have resulted in a greater number of positive films. However, we do not feel that x-ray evidence is of sufficient value, except in the rare diagnostic problem, to waste time or further burden the patient by a more careful technique. We would not condone the injection of air through a stomach tube in order to demonstrate a perforation, as has been advocated by some authors.

*Location of Perforation.*—As in all groups, there was some difficulty in classifying those ulcers located near the pylorus. Eight, or 9.1 per cent of the perforations were located at the pylorus. Of the remainder, nine, or 10.2 per cent were definitely gastric, and seventy-one, or 80.7 per cent were duodenal. DeBakey placed this relationship as 38.9 per cent gastric, 51.2 per cent duodenal, and 9.8 per cent pyloric in the collected series.[4, 5]

*Postoperative Complications.*—Except as a cause of death, peritonitis cannot be considered a complication of this disease, since all of these patients have either a chemical or a bacterial peritonitis or both from the start; and a startlingly high per cent of patients who have been perforated over six hours do have positive peritoneal cultures.

As in all other series, our commonest complication was wound infection. This occurred in nine instances, or 10.2 per cent of our patients. Eight of these were subcutaneous infections which healed readily, and one was a deep wound infection which healed after a prolonged period. There were no persistent sinuses, although nonabsorbable sutures were used throughout. DeBakey's collected series had 25 per cent wound infections.[4, 5]

One patient suffered a complete wound separation and evisceration on his eleventh postoperative day. This was closed at once with through-and-through wire sutures under local anesthesia, and promptly healed without further difficulty.

There were four subphrenic abscesses: all drained anteriorly; three patients had a significant postoperative atelectasis; two patients developed pneumococcus pneumonia; one patient had a massive hemorrhage from his ulcer site and was treated by transfusion; and one patient began an auricular fibrillation with cardiac decompensation. All of these were treated appropriately and recovered.

*Mortality Rate.*—In this group of eighty-eight patients operated upon, there was one death, a mortality rate of 1.1 per cent, which is the lowest published for significant numbers of patients with this condition. A glance at Table III will demonstrate the contrast of this mortality with that apparently prevalent in the large hospitals and clinics throughout the country. Tilton's[3] and Graham's[1, 2] reports were admittedly of a low mortality risk according to the

TABLE III. MOST RECENTLY PUBLISHED MORTALITY RATES FOR PERFORATED PEPTIC ULCER

| AUTHOR | YEAR | NUMBER CASES | PER CENT MORTALITY |
|---|---|---|---|
| Baritell, A. L. | 1946 | 88 | 1.1 |
| Tilton, B. J. | 1936 | 52 | 2.0 |
| Graham, R. R. | 1938 | 62 | 3.2 |
| McClure, R. D. | 1940 | 91 | 7.7 |
| Estes, W. L., and Bennett, B. A. | 1944 | 80 | 8.7 |
| Black, B. M., and Blackford, R. E. | 1945 | 93 | 12.0 |
| Barber, R. F., and Madden, J. L. | 1943 | 86 | 12.8 |
| Hartzell, J. B., and Sorock, M. L. | 1939 | 39 | 12.8 |
| Marshall, S. F., and Keleher, P. C. | 1940 | 46 | 13.0 |
| Raw, S. C. | 1944 | 312 | 14.4 |
| Cohn, R. | 1941 | 300 | 15.0 |
| Berson, H. L. | 1942 | 151 | 15.2 |
| Ross, J. C. | 1940 | 175 | 16.0 |
| Paletta, F. X., and Hill, W. R. | 1943 | 83 | 16.9 |
| DeBakey, M., and Odom, C. B. | 1940 | 211 | 17.3 |
| Ross, A., and Letourneau, G. | 1939 | 220 | 17.7 |
| Donald, D. C., and Barkett, S. M. | 1942 | 116 | 18.5 |
| Meade, R. H. | 1943 | 68 | 19.1 |
| Timoney, F. X. | 1943 | 246 | 19.5 |
| Griswold, A. R., and Antoncic, R. | 1941 | 102 | 19.6 |
| Fallis, L. S. | 1938 | 100 | 20.0 |
| McCreery, J. A. | 1938 | 170 | 20.5 |
| Eliason, E. L., and Thigpen, G. M. | 1938 | 70 | 21.4 |
| Sangster, A. H. | 1939 | 100 | 23.0 |
| O'Donoghue, J. B., and Jacobs, M. | 1942 | 200 | 24.5 |
| McCabe, E. J., and Mersheimer, W. | 1943 | 87 | 25.2 |
| Martz, H., and Foote, M. H. | 1940 | 50 | 26.0 |
| Parker, E. F. | 1941 | 52 | 27.0 |
| Davidson, T. C., and Rudder, F. F. | 1940 | 155 | 28.0 |
| Thompson, H. L. | 1939 | 424 | 28.7 |
| Hartzell, J. B., and Sorock, M. L. | 1939 | 234 | 28.9 |
| Reed, J. C. | 1938 | 100 | 30.0 |

usual standards. It is probable that the mortality has been even higher in the hands of the casual surgeon who sees only an occasional perforated ulcer. It has already been shown that our group was not more favorable material than that reported in other series. However, it is acknowledged and hoped that mortality rates in the last three years, not yet reported, will be much lower than they have been for the preceding twenty years.

This can be expected on the basis of the use of chemotherapy and the utilization of all of the basic surgical principles already known, in every case of perforated ulcer. Surgeons who persist in advocating such proved unsound principles as drainage of the peritoneum or adding accessory procedures to simple closure may expect to continue to lose every fifth or sixth patient.

It is unfortunate and a stimulus to ourselves not to relax our constant vigilance and best efforts for these patients that our one death was preventable. This patient was 49 years of age and was operated fifteen hours after his perforation had taken place. He was known to have rheumatic heart disease with mitral stenosis. Twenty-four hours postoperatively he developed acute pulmonary edema and died in an hour despite rapid intravenous digitalization, aminophylline, hypertonic sucrose, morphine, and atropine, 95 per cent oxygen, and tourniquets. Autopsy confirmed the cause of death. It is believed that more judicious administration of fluids postoperatively would have prevented this catastrophe.

*Hospital Days.*—This group of patients spent an average of 14.3 postoperative days in the hospital, with extremes of eight and forty-one days. This is considerably less than any previous report, and is in part due to the use of nonabsorbable sutures with early ambulation, and in part to the care exercised to prevent complications.

*Rate of Incorrect Diagnosis.*—Only two patients were explored with a mistaken diagnosis and found to have a perforated ulcer. Both of these were operated through McBurney incisions for a perforated appendix with generalized peritonitis, and found to have perforated ulcers. In each case, the appendix was removed, a new incision made, and the perforation closed with recovery. Three patients were operated with a diagnosis of perforated ulcer and found to have other pathology. These were an acute gall bladder, which was removed, an acute perforated appendix, which was removed, and an acute interstitial pancreatitis. All of these patients recovered. No perforated ulcer failed to be recognized as an acute surgical emergency, and no patient died as a result of mistaken diagnosis.

*Nonoperative Patients.*—Five patients were seen with a presumptive diagnosis of a perforated ulcer whose signs and symptoms were subsiding and were over twelve hours since the onset of their pain. They were treated conservatively according to the plan advocated by Wangensteen with recovery in all cases.[10] One of these developed a subphrenic abscess which required drainage. We do not advocate this type of management except after the most careful evaluation and with constant observation. At the first indication of increasing signs they should be operated at once. No mortality should ever be risked by conservative management of this type of patient.

Only two other patients with perforated ulcers were not operated. One of these was a young man who entered with a recent perforation but who emphatically and insistently refused surgery until his death from peritonitis thirty-six hours after entry. The other was a 63-year-old man who entered the hospital moribund and died in a few hours. He had a history of two to three days of peritonitis, and was proved at autopsy to have a perforated ulcer.

## METHOD OF TREATMENT

*Preoperative Measures.*—The one controllable factor which is of great importance in its effect on the mortality rate is that of the time elapsing between perforation and surgical treatment. Because of the severity and suddenness of these patients' symptoms, they nearly always seek medical aid early, but frequently do not receive such, through no fault of their own. Any acute abdomen deserves immediate attention from the physician and should take precedence over most other patients in the hospital and operating room. It is not our purpose to discuss diagnosis, which is usually made quickly and easily. It should be a matter of minutes between the time such a patient arrives at the hospital until he is on his way to the operating room. Time only to do a physical examination and prepare the abdomen need be taken. Laboratory work can be done while this is being carried out and x-rays can be taken on the way to the operating room or both can be dispensed with. The occasional

diagnostic problem may require more time, but there is little to be gained and much to be lost in wasting time on a patient who is certainly going to require laparotomy anyway.

We do not advocate the placement of a gastric suction tube preoperatively, but do not condemn it. We feel that the retching which may be induced results in greater soiling of the peritoneum and that the passage of such a tube through the mouth or nose and pharynx with the perforation still open must carry down further organisms which have access to the peritoneum. If the patient is to be treated conservatively or if delay before surgery is necessary, continuous suction should be instituted at once.

Soutter[11] and others have shown that true shock is rarely a part of the picture of perforated ulcer in the absence of other causes. Time need not be lost in treating the appearance of shock when it is not present. We feel that the intravenous administration of 5 Gm. of sulfadiazine in 500 c.c. of ⅙ molar sodium lactate should be begun in the emergency room or the operating room in all instances of peritonitis.

*Anesthesia.*—It has been repeatedly shown that spinal is almost always the anesthetic of choice, and such is our routine. In the face of the usual contraindications for spinal anesthesia or the patient's refusal of such anesthesia, we have found that intravenous Pentothal with local anesthesia is well tolerated by these patients.

*Operative Method.*—The incision should be short.[12, 13] Exposure is adequate through an 8 to 10 cm. incision which may be either rectus-splitting or transverse. Small incisions are important because these patients are quite prone to develop wound infections and separations.

The perforations are generally readily apparent on the anterior surface of the stomach or duodenum. All gastric ulcerations should be biopsied; and even though the biopsy is benign, the patient should be followed postoperatively with the same suspicion as the gastric ulcer patient who has not perforated. He should be subjected to gastric resection for the customary indications. One of our patients had a negative biopsy from a perforated gastric ulcer but was lost from our clinic postoperatively until he returned one year later and was explored for an unresectable carcinoma of the stomach.

The next step is closure of the perforation. This may be done with a single row of interrupted Lembert sutures of cotton placed in the longitudinal axis of the bowel with a tag of fat tied over these. Purse strings or repeated layers of closure are unnecessary, tend to obstruct the lumen of the bowel, and generally are tied in such a manner as to cut through or necrose tissue by pressure.

The one very definitely new and valuable contribution we have to offer in regard to surgical technique is the method of closure which we have developed and advocate very strongly in the presence of edema and induration about the site of perforation. The difficulty of obtaining a satisfactory closure under these circumstances is well known and has led to the ingenious method described by Gatch and Owen.[14] When the customary closure is accomplished

under such conditions there is danger of obstruction. Perhaps less appreciated but more important is the danger of the sutures cutting through, or of sufficient necrosis of tissue due to their tension to allow further leakage to develop. These difficulties are entirely absolved by the very simplest of methods which we have used with complete success in twenty instances. To our knowledge, no regular use of this method has ever been described, although several authors make brief mention of occasional use of what seems to be the same means of closure.[12, 15-18]

Senn[19] in 1891 first suggested the use of a portion of the greater omentum as a protection in operations on the hollow viscera. In 1896, Bennett[19] reported the case of a perforated gastric ulcer closed by an omental plug into the perforation with recovery.[19] It has long been our practice in the presence of much edema or induration about a perforation, and it is now our routine, to close all perforated ulcers of the stomach and duodenum by simply tacking a tag of living omental fat over the perforation with a few interrupted cotton sutures. No attempt whatever is made actually to close the perforation, and no suture is passed through the bowel wall as Graham describes.[1, 2] A bit of gastrohepatic omentum is usually most readily available for this purpose. The surgeon need feel no insecurity in this method. Watertight closure is entirely unnecessary. Twenty of our patients have been so treated with no complications and with the same rapid recovery as the others. This method should always be used in the presence of induration and edema.

The importance of the simplest workable procedure in closure of perforations is generally recognized, although some authors still persist in advocating such accessory procedures as gastroenterostomy, which has almost no place in the treatment of duodenal ulcer at any time.[20] The omental patch is certainly the simplest means of covering the perforation which is surrounded by a large area of induration.

All free fluid should be sucked from the peritoneum, giving particular care to the spaces about the liver, the right gutter, and the pelvis. The abdomen is closed in layers with interrupted cotton sutures. No drains are placed either in the peritoneum or the wound. The former is not only utterly useless but may be harmful, while the latter is probably of little value, since 90 per cent of our wounds healed per primam. We could offer no criticism of drainage of the wound, however, in the presence of obvious suppuration. The entire operative procedure should not require over an hour and is usually much less.

*Postoperative Care.*—Immediately on return from the operating room, the patient has a nasal tube passed into his stomach, to which continuous suction is applied for approximately forty-eight hours. At the end of this period, if the patient has good peristalsis, the tube is clamped off for a period of four hours. If there is less than 100 c.c. retention in the stomach, the tube is removed and oral intake of graduated amounts of water at hourly intervals is begun. After another thirty-six hours, the patient is given fluids as desired and placed on a graduated soft diet. It is very important that the suction be kept functioning while it is in place; and this requires constant observation and care. The tube invariably becomes obstructed and needs opening up or

replacement. The suction apparatus may develop leaks or become plugged up. Failure to keep continuous suction working the first twenty-four hours may result in disaster.

The routine postoperative fluids consist of 2,000 c.c. of 5 per cent glucose in saline, 1,000 c.c. of 5 per cent glucose in water, and 500 c.c. of ⅙ molar sodium lactate administered intravenously daily. This is varied according to individual needs. Intravenous amino acids are given to older patients, those in poor nutrition, and those who have a more severe bacterial peritonitis. As fluids are begun by mouth, the intravenous administration is gradually discontinued. Sulfadiazine is administered intravenously and then orally in doses sufficient to maintain levels of 8 to 12 mg. per cent. No penicillin has been used.

The use of sulfonamides in the contaminated peritoneum and wound has been entirely discontinued.[21] In a considerable group of patients so treated, including a significant number with perforated appendicitis, we have had no deaths. Although our mortality rate in those patients who had intraperitoneal sulfonamides was fully as good as our present rate, there were certain undesirable complications which have led us to discontinue the local use of these drugs entirely. This will be reported more fully in the future.

All of our postoperative patients except those with bacterial peritonitis are allowed early ambulation. This also applies to perforated ulcers, although the process of getting them out of bed is not applied quite so strenuously on the first two postoperative days as with other patients. We feel that this program has markedly reduced postoperative complications, particularly pulmonary and thromboembolic, has reduced the hospital stay, and has shortened convalescence. If nonabsorbable suture material is used, there should be no increased danger of wound separation.

## CONCLUSIONS

1. A group of eight-eight patients has been operated for perforated gastric and duodenal ulcers with a mortality rate of 1.1 per cent.

2. This series is in every way comparable to other groups reported in regard to mortality risk.

3. A new, or at least heretofore unpublicized, technique of operative treatment, consisting of applying an omental patch to the perforation without any attempt at closure, has been applied to twenty patients with uniform success. It is now our routine in all cases and is strongly recommended in any patient in which there is marked edema or induration about the perforation.

4. The combination of organized teamwork in the rapid diagnosis and institution of definitive therapy in surgical emergencies together with the use of chemotherapy and the application of sound, well-recognized, surgical principles has resulted in a very low death rate for a disease which heretofore carried a formidable mortality rate. We believe that similar results could be obtained more generally.

## REFERENCES


1. Graham, R. R.: The Treatment of Perforated Duodenal Ulcers, Surg., Gynec. & Obst. **64**: 235-238, 1937.
2. Graham, R. R.: The Surgeon's Problem in Duodenal Ulcer, Am. J. Surg. **40**: 102-117, 1938.
3. Tilton, B. J.: Low Mortality of Early Operation for Perforated Gastric and Duodenal Ulcer, Am. J. Surg. **32**: 238-240, 1936.
4. DeBakey, M.: Acute Perforated Gastroduodenal Ulceration, SURGERY **8**: 852-884, 1940.
5. DeBakey, M.: Acute Perforated Gastroduodenal Ulceration, SUGERY **8**: 1026-1076, 1940.
6. DeBakey, M., and Odom, C. B.: Significant Factors in the Prognosis and Mortality of Perforated Peptic Ulcer, South. Surgeon **9**: 425-436, 1940.
7. Cohn, R.: Repeated Perforations of Peptic Ulcers, SURGERY **9**: 688-694, 1941.
8. Barber, R. F., and Madden, J. L.: Acute Gastroduodenal Perforation, Am. J. Surg. **59**: 484-495, 1943.
9. Kelly, M. W.: Acute Perforated Peptic Ulcers, SURGERY **6**: 524-534, 1939.
10. Wangensteen, O. H.: Non-Operative Treatment of Localized Perforations of the Duodenum, Minnesota Med. **18**: 477-480, 1935.
11. Soutter, L.: Shock in Perforated Peptic Ulcer, SURGERY **10**: 233-241, 1941.
12. Black, B. M., and Blackford, R. E.: Perforated Peptic Ulcer: Review of Ninety-Six Cases, S. Clin. North America **25**: 918-928, 1945.
13. Hartzell, J. B., and Sorock, M. L.: Acute Perforated Peptic Ulcer, Surg., Gynec., and Obst. **69**: 668-670, 1939.
14. Gatch, W. D., and Owen, J. E.: The Technique of Closing Perforated Ulcers of the Duodenum, Ann. Surg. **105**: 750-757, 1937.
15. Marshall, S. F., and Keleher, P. C.: Management of Acute Perforation of Peptic Ulcer, S. Clin. North America **20**: 757-766, 1940.
16. Price, P. B., and Lee, T. F.: The Use of Omentum to Close Perforations of the Stomach, Arch. Surg. **50**: 171-173, 1945.
17. Trout, H. H.: Acute Perforations of Peptic Ulcers, Am. J. Surg. **46**: 621-624, 1939.
18. Ulfelder, H., and Allen, A. W.: Acute Perforation of the Stomach and Duodenum, New England J. Med. **227**: 780-784, 1942.
19. Bennett, W. H.: Closure of Perforated Gastric Ulcer by Omental Plug With Recovery, Lancet **2**: 310-311, 1896.
20. Baritell, A. L., and Henley, R. B.: Subtotal Gastrectomy, Permanente Found. M. Bull. **3**: 64-75, 1945.
21. Harvey, H. D., Meleney, F. L., and Rennie, J. W. R.: Peritonitis, SURGERY **11**: 244-260, 1942.

# INTUSSUSCEPTION OF EXCLUDED DISTAL ILEUM WITH SPONTANEOUS EXPULSION PER ANUM OF SEQUESTRATED INTUSSUSCEPTUM

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FITZWILLIAMS,[3] in 1908, reported 1,000 cases and in 1921 Perrin and Lindsay[6] reported 400 cases of intussusception without a single instance of slough with spontaneous recovery.

Garlock[4] stated that intussusception of the excluded terminal ileum was discovered inadvertently in two cases in which ileocolic resection was undertaken as a second stage operation for terminal ileitis.

A review of the literature for the past twenty years discloses a small number of cases[1, 5, 7-12] wherein a spontaneous cure resulted following the expulsion per anum of the sequestrated intussusceptum. However, in only one instance has a condition somewhat similar to the present one been reported. In that case ileocolic invagination developed after the section and exclusion of the distal ileum with ileotransverse colostomy, but the condition was not relieved spontaneously. In this case, reported by d'Allaines and Martin,[2] the first stage operation consisted of an ileotransverse colostomy with exclusion of the distal ileum for a carcinoma of the hepatic flexure of colon. On the third post-operative day the patient developed fever, colic, and frequent diarrheal stools with passage of blood and mucus. Six weeks later, in spite of progressive weight loss and cachexia, the second stage was performed. At this operation the invagination was discovered. The specimen resected consisted of the last 30 cm. of ileum, the right colon, and part of the transverse colon; 14 cm. of the ileum had become invaginated within the excluded loop.

Treves[12] explained the pathologic process of spontaneous recovery in two ways: Adhesions form between the peritoneal surfaces of the entering portion and the ensheathing portions of the intestine. If a separation takes place first at the end of the middle layer, the intussusception will straighten out at the apex. Later, as separation takes place in the middle layer near the entering portion of the intestine, the section will be passed with its peritoneal layer outermost. If the separation takes place at the two ends of the middle layer in the reverse order, the section will be passed with the mucous surface outermost. The former is the common one, and the latter with the intestine turned inside out is relatively rare. The intestine in all cases is gangrenous and macerated.

## CASE REPORT

*History.*—E. R., a 48-year-old white woman, was first seen in 1940, complaining of recurrent attacks of abdominal cramps associated with nausea, vomiting, and diarrhea. She had had a left salpingo-oophorectomy fifteen years previously followed by menopause; she had had a left ureterolithotomy six years previously. Since this latter operation she suffered mild frequency, urgency and dysuria associated with albuminuria and pyuria.

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After a very thorough examination in the Consultation Clinic at the Mount Sinai Hospital, it was concluded that the patient was suffering from ulcerative colitis, right nephrolithiasis, double left kidney, trigonitis, and urethral caruncle.

*First Admission.*—The patient was first admitted to the Mount Sinai Hospital on March 24, 1940, and discharged on April 27, 1940. She was admitted chiefly because of a nutritional problem, since she weighed only 93 pounds and was 65 inches tall. The urinary symptoms had been minimal since the ureterolithotomy. Since June, 1939, she had had recurrent attacks of abdominal cramps, nausea, vomiting, diarrhea, and fever. These acute attacks lasted about one or two weeks and recurred almost every month.

Sigmoidoscopy revealed a normal rectum and sigmoid, but there was blood and mucus coming from above, where a lesion was presumed to exist. Repeated x-ray studies revealed a normal esophagus and a ptosed stomach, with no evidence of organic intrinsic lesion. The duodenal bulb was dilated but complete with no irregularities in outline. The small bowel was studied at short intervals and showed no abnormality in the jejunum or proximal ileum. The terminal three inches of ileum showed distinct irritability. It was distensible yet tended toward an inconstant narrowing. The right half of the colon was distended, revealed gas in the preliminary examinations, and showed marked loss of haustrations. The appearance suggested the likelihood of an inflammatory process involving the terminal ileum and probably the colon also. Preliminary x-ray examination showed irregular calcifications in the right upper quadrant in the region of the right kidney.

During this hospital stay the patient was seen by several consultants who concluded that operation should not be done, because there was insufficient evidence of organic change in the bowel. The patient was thought to be a very nervous and hysterical type, so that treatment was directed toward the malnutrition, avitaminosis, and diarrhea. By means of a nonresidue diet, large amounts of all vitamins parenterally, neoprontosil, and spasmalgin, she showed progressive improvement. Weight increased from 93 pounds to 100 pounds and stools diminished from eight to three a day.

*Second Admission.*—Shortly after the patient's discharge from Mount Sinai Hospital, there was a recurrence of the cramps, diarrhea, and loss of weight. She was readmitted on Feb. 22, 1941, and discharged on April 12, 1941. During this stay she was found to be pale, markedly underweight, and dehydrated. The cecum could be rolled under the fingers with only slight tenderness. Otherwise the abdomen was negative.

X-ray views of the chest revealed calcified areas in the left apex due to an old tuberculous process. New roentgenograms of the intestines revealed considerable loss of haustration of the entire colon with numerous constricted areas. The terminal ileum was similarly involved, suggesting a diffuse inflammatory process. Blood showed hemoglobin, 90 per cent; white blood cells, 13,000 with a normal differential. Sedimentation rate was 11/4 hours. Wassermann reaction was negative. Blood calcium was 11.2 mg. and phosphorus 3.6 mg.; phosphatase was 6.5 King Armstrong units; sugar 125. mg.; chlorides 560 mg.; blood sodium 133.7 meq. per liter. Urine contained a trace of albumin, a rare red blood cell, and a moderate number of white blood cells. Stool was negative. Basal metabolic rate was plus 17 per cent. Electrocardiogram showed a low Tl, ST transition in 11, and 111 slightly depressed. Rehfuss test meal gave normal results; Frei, negative.

It was now felt that the bowel symptoms were attributable to organic changes and accordingly an ileosigmoidostomy was performed. At this operation the terminal ileum, the cecum, ascending colon, and proximal transverse colon were found to be the site of a chronic inflammatory process. The terminal ileum about 16 inches from the ileocecal junction was divided, both ends inverted, and the proximal loop anastomosed laterally to the sigmoid. The mesentery of the ileum had been widely divided at the site of exclusion of the terminal ileum, but no attempt had been made to suture it. The patient had a rather stormy postoperative course, but then showed progressive improvement until discharge.

*Third Admission.*—About two weeks following her discharge from Mount Sinai Hospital, the patient developed intestinal obstruction characterized by abdominal cramps, vomiting, and constipation. She was admitted to another institution where this diagnosis was confirmed by roentgenograms, showing small bowel loops distended with gas and fluid levels.

A Miller-Abbott tube was successfully passed and the small bowel decompressed. The tube was in place for two weeks when she was readmitted to the Mount Sinai Hospital on May 13, 1941, and discharged on June 3, 1941. A tender mass was felt in the right lower quadrant of the abdomen. After adequate decompression, x-ray examination showed barium injected through the Miller-Abbott tube to pass through the ileosigmoidostomy satisfactorily. Because of x-ray evidence that the obstruction was relieved, the Miller-Abbott tube was removed. The patient continued to take food by mouth and pass stool per rectum. There were no further symptoms of obstruction. Intermittent diarrhea occurred on several occasions. When she left the hospital there was some edema of the legs.

Follow-up at the clinic on Sept. 4, 1941, showed that the patient's general condition had improved markedly. She had gained twenty pounds. The wound was well healed. Bowels moved three or four times a day. On March 4, 1942, the patient looked well and had gained twenty-five pounds in all since the original operation. She still complained of intermittent pain in the right lower quadrant where a mass seemed to be felt.

*Fourth Admission.*—Since 1941 when the ileosigmoidostomy was performed, the patient had had several episodes of intestinal obstruction successfully relieved by the use of the Miller-Abbott tube. In the latter part of May, 1942, she developed another such episode which did not respond very well to intubation. Therefore, she was readmitted to the Mount Sinai Hospital June 19, 1942, and discharged Aug. 19, 1942. During this stay she was found to be chronically ill, anemic, dehydrated, and showing evidence of marked inanition. With the Miller-Abbott tube in place there was no abdominal distention and only slight tenderness in the right lower quadrant. There were three well-healed scars on the lower abdomen: (1) left ureterolithotomy, (2) salpingo-oophorectomy, (3) ileosigmoidostomy.

On June 20, 1942, operation was carried out through a left lower paramedian incision. The end of the Miller-Abbott tube was found to reach almost to the ileosigmoidostomy, the stoma of which was satisfactory. The cause of the obstruction was seen to be due to the insinuation of a loop of small bowel beneath the free margin of the mesentery of the ileum just proximal to the anastomosis. The obstruction was easily relieved and the free edge of the mesentery was sutured to the posterior parietes.

For about two weeks postoperatively the course was smooth with resumption of frequent loose bowel movements. Then the patient again developed nausea, vomiting, obstipation, and fever. Further attempts at intubation failed. On the tenth postoperative day the lower angle of the wound was inflamed with progressive suppuration, so that it was necessary to incise and drain the wound one month following this last operation. It was felt that intraperitoneal suppuration existed as well as that in the wound. Further progress was slow and at the time of discharge from the hospital, the wound showed clean granulations with no evidence of suppuration.

*Fifth Admission.*—The patient was at home for only eleven days when she was again readmitted, Aug. 30, 1942, and discharged, Oct. 21, 1942. On the day before this admission she suffered severe lower abdominal cramps with nausea and persistent vomiting. An enema had been fairly effectual. She still appeared chronically ill and poorly nourished. The abdomen was moderately distended. A nontender immobile sausage-shaped mass was palpated in the right lower quadrant. Numerous borborygmi were heard. Rectal examination revealed a small amount of stool. Hemoglobin was 60 per cent, white blood cells were 12,200. Urine contained albumin and acetone. Blood culture was sterile. An intravenous infusion was again started and an attempt was made to pass the Miller-Abbott tube. The mass in the right lower quadrant became tender and the temperature rose to 103° F. Some sort of pericolonic exudate was thought to exist and accordingly sulfathiazole was administered. About one week later the mass was noted in the umbilical region. The fever gradually subsided. Two weeks later, after a few days of intensely severe cramps, the patient noted a mass extruding from the rectum. This was a portion of gangrenous bowel which was completely extruded in the next twelve hours. It measured fifteen inches in length. Following this she felt well. In view of the disappearance of the mass from the right lower quadrant and subsequently from the umbilical region, it was concluded that the extruded

bowel was the excluded portion of terminal ileum. One week later another smaller, tender mass appeared in the right lower quadrant. This was interpreted as an inflammatory reaction about the site of the previous intussusception. Two weeks later the mass was no longer palpable. The patient was afebrile, eating well and having several bowel movements daily. A barium enema was made and the x-ray views revealed the abnormality in the colon, due to the colitis noted originally in 1940 (Fig. 1). In addition, the cecum and ascending colon failed to fill out (Fig. 2). This defect was interpreted as a result of the intussusception of the ileum, cecum, and ascending colon.

**Fig. 1.**—Roentgenogram made with barium enema, March 15, 1940, about one year prior to operation, shows evidence of colitis involving particularly the ascending and transverse colon. Note the narrowing of the terminal ileum and the position of the cecum which is missing in the view taken after operation. (Ileosigmoidostomy with exclusion, March, 1941.)

*Follow-up Record.*—On Dec. 17, 1942, the patient stated that she had been remarkably well since discharge from the hospital. She had gained more than seventeen pounds. Stools were solid with occasional diarrhea, and pain in the right lower quadrant and about the umbilicus. She had had one episode of biliary colic with jaundice, both of which cleared up spontaneously. On June 17, 1943, she had gained thirty pounds since discharge from the hospital. She still complained of diarrhea with seven bowel movements a day and occasional periumbilical pain.

*Sixth Admission.*—The patient was readmitted on Sept. 17, 1943, and discharged on Oct. 22, 1943, because of an incisional hernia. She had left the hospital about ten months

previously after a prolonged illness. The most recent operative wound had become infected and was drained on several occasions. This resulted in an incisional hernia to the left of the midline in the lower abdomen. Three steel wire sutures had remained and from time to time had penetrated the subcutaneous tissues producing painful hematomas. At operation the scar was excised and the fascia exposed for two inches all around the defect. Three steel sutures were removed and the defect repaired by mattress sutures of chromic catgut without incising or opening the fascia or peritoneum. She vomited considerably for the first few days postoperatively. This was controlled by Levine tube and intravenous infusions. Three weeks following operation the patient was out of bed and eating an unusually large

**Fig. 2.—Roentgenogram made with barium enema, Oct. 20, 1942, about one month following spontaneous extrusion per anum of intussusception, consisting of excluded terminal ileum. Note absence of cecum and ascending colon due to persistent intussusception.**

fatty meal, whereupon typical biliary colic developed with fever and subsequent mild jaundice. There were tenderness and moderate rigidity in the right upper quadrant. Icteric index rose to twelve. Cholecystography with double dose of dye repeated on two days failed to visualize the gall bladder.

*Final Admission (Seventh).*—The patient was admitted to the Mount Sinai Hospital Nov. 29, 1943, and discharged Dec. 21, 1943, because of several previous attacks of biliary colic, with fever and jaundice and failure to visualize the gall bladder on cholecystography. At operation the abdomen was entered through an oblique incision seven inches in length

extending from the ensiform to a point two inches lateral to the umbilicus. The gall bladder was distended to twice the normal size, adherent to the common bile duct and duodenum, and contained four pigmented stones 3 to 7 mm. in diameter. The common bile duct was explored and a stenosis was found at its lower portion where a probe could be passed into the duodenum with difficulty. Bockus dilators were introduced with gradual dilatation of the stricture and sphincter. A T tube was inserted and the gall bladder was removed. The

Fig. 3.—Roentgenogram made with barium enema following evacuation, Dec. 8, 1944, about two years following spontaneous extrusion of sloughed ileum. Evidence of colitis persists. Note incomplete filling of cecum due to persistent infolding; contrast outline and position of cecum with that in Figs. 1 and 4.

right lower quadrant was not thoroughly explored because of extensive adhesions and because of the position of the laparotomy incision. However, the mass felt from time to time in the right lower quadrant was palpated intra-abdominally and ascertained to be the cecum or ascending colon or both. Therefore, partial intussusception of these portions of the bowel was presumed still to exist.

Following the cholecystectomy and common duct drainage the patient had a smooth postoperative course. Cholangiogram made two weeks after operation showed the dye to enter the duodenum readily. There was no abnormality in the extrahepatic biliary ducts. The T tube was withdrawn on the seventeenth postoperative day and she was home three weeks after operation.

*Follow-up Notes.*—March 16, 1944, general condition of the patient was excellent. All scars were well healed. She had five or six bowel movements daily, but suffered no pain or discomfort.

On Dec. 7, 1944, she had suffered some pain in the right lower quadrant for a few days. In view of the history and the presence of a mass in the right lower quadrant without symptoms of obstruction, a barium enema was made. This showed the stoma between the ileum and sigmoid to be functioning well. The colon again showed the loss of haustration, the smoothness of outline, and irregularities noted in 1940 and 1942. At this time (Fig. 3) the evacuation film disclosed better filling of the ascending colon, but the cecum was not completely filled, indicating persistent infolding of this part of the bowel.

Fig. 4.—Roentgenogram made with barium enema, Jan. 3, 1946, about 3½ years following extrusion of excluded ileum. Note the complete filling of the cecum and the improved appearance of the colon. On the medial aspect of the cecum at the site of the ileocecal valve is seen a small projection which is interpreted to be the remains of the sloughed ileum.

On Jan. 4, 1945, the patient felt well except for moderate persistent pain in the right lower quadrant. She had an average of six bowel movements a day. She maintained her weight. All abdominal scars were well healed without hernias. The anatomic, symptomatic, and economic results were estimated as good.

On July 5, 1945, she continued to have mild pain in the right lower quadrant, but there were no further symptoms of intestinal obstruction.

*Final Admission (Eighth).*—Because of recurrent attacks of pain in the right lower quadrant of the abdomen, the patient was admitted to the Mount Sinai Hospital Jan. 2, 1946, and was discharged on Jan. 8, 1946. A right retrograde pyelogram revealed the stones in the right kidney pelvis to have increased in size to a slight degree. However, the right kidney pelvis showed no hydronephrosis. Renal function was good. Sigmoidoscopy to the extent of eight inches revealed no abnormality in the rectum or lower sigmoid. A barium enema (Fig. 4) revealed the entire cecum to fill out at this time in contrast to roentgenograms made in 1942 and 1944 (Figs. 2 and 3). There was no longer any evidence of intussusception of the cecum. Moreover, a small defect seen on the medial wall of the cecum near the ileocecal valve was interpreted as the remaining stump of the ileum which had sloughed off in 1942. Since the colon showed no further retrogression of the preexisting colitis and the infolding of the cecum had been reduced by repeated enemas, no indication for operation (possible colectomy) was present.

## SUMMARY OF CASE REPORT

The case reported is that of a 48-year-old white woman first seen in 1940 for nonspecific ileocolitis of two years' duration. Immediately following ileosigmoidostomy with division and exclusion of the distal ileum, she developed repeated attacks of small bowel obstruction. For one year these bouts were controlled by the prolonged use of an indwelling Miller-Abbott tube. The longest such period of decompression was three weeks.

Finally, operation disclosed the obstruction to be due to the insinuation of the ileum behind the mesentery of the divided terminal ileum used in the ileosigmoidostomy. An intra-abdominal abscess and wound infection followed this "clean" operation wherein the bowel was neither opened nor unduly manipulated.

Recurrent abdominal pain, distention, and fever were accompanied by a mass in the right lower quadrant, which, later, seemed to move to the umbilical region. All the abdominal symptoms subsided with the passage of a gangrenous segment of bowel which was presumed to be the excluded loop of terminal ileum.

The sequence in which the patient submitted to operation was:

1. Salpingo-oophorectomy followed by menopause, 1925.
2. Left ureterolithotomy, 1934.
3. Ileosigmoidostomy with exclusion, February, 1941.
4. Release of small bowel obstruction due to insinuation of ileum beneath mesentery, June, 1942.
5. Several incisions and drainage for intra-abdominal abscess and wound infection, July and August, 1942.
6. Repair of incisional ventral hernia, September, 1943.
7. Cholecystectomy and common duct drainage, December, 1943.

## COMMENTS AND CONCLUSIONS

1. The intussusception of the excluded distal loop of ileum is most unusual. It has been reported only once in the literature and on that occasion spontaneous expulsion of the intussusceptum did not occur as in the case herein reported.

2. Garlock's observation of intussusception of the excluded ileum in two cases (unreported) and in the case under discussion indicates that ileocolostomy

with exclusion cures the disease in the terminal ileum. Intussusception could hardly be expected to develop in the ileum unless it were sufficiently distensible.

3. Intestinal obstruction following operations for colitis is known to be rather common. Usually it is due to postoperative bands or adhesoins. However, the cause of the obstruction may be varied. In this case it proved to be due to (1) insinuation of the ileum behind the divided mesentery near the stoma, (2) wound infection, and (3) intussusception of the excluded ileum.

4. In performing ileocolostomy with exclusion both the divided mesentery and the terminal ileum should be tacked down to prevent the two complications observed in this case.

5. This case represents a triumph for the several surgeons who contributed in the treatment of a woman who, although she appeared neurotic, invariably developed definite evidence of organic disease.

6. In spite of seven major operations and at least twelve hospital admissions during which she was frequently close to death, she finally achieved a state of well-being.

REFERENCES

1. Bockoven, W. A.: J. Iowa M. Soc. **26**: 257-258, 1936.
2. d'Allaines, F., and Martin, J. P.: Arch. d. mal. de l'app. digestif. **26**: 944-946, 1936.
3. Fitzwilliams, D. C.: Lancet **1**: 628-707, 1908.
4. Garlock, John H.: Personal communication.
5. Mayo, C. W.: Proc. Staff Meet., Mayo Clin. **3**: 345-346, 1932.
6. Perrin, W. S., and Lindsay, E. C.: Brit. J. Surg. **9**: 46, 1942.
7. Podetti, V.: Arch. per le sc. med. **67**: 313-361, 1939.
8. Segall, E.: Polska gaz. lek. **18**: 232, 1939.
9. Szlavik, F., Jr.: Arch. f. Kinderh. **126**: 2-5, 1942.
10. Szlavik, F., Jr., and Farkas, K.: Budapesti orvosi ujság **39**: 145-147, 1941.
11. Thompson, L. D.: Am. J. Dis. Child. **34**: 640-643, 1927.
12. Treves, Frederick: Intestinal Obstruction, 1921.
13. Zashvili, N. P.: Novy khir. arkhiv. **42**: 426-427, 1938.

# INTERMITTENT EXTERNAL BILIARY DRAINAGE FOR RELIEF OF PRURITUS IN CERTAIN CHRONIC DISORDERS OF THE LIVER

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IN CERTAIN chronic disorders of either the hepatic parenchyma or intrahepatic biliary system, intractable itching is an unpleasant feature. The pruritus in these patients has been commonly ascribed in medical textbooks to an abnormal accumulation of serum bile salts. These individuals frequently suffer miserably from this unremitting annoyance, and their generalized cutaneous excoriations attest to the transient or incomplete relief obtained through the therapy customarily employed. D.H.E. (dihydroergotamine), injected intramuscularly, will often control the pruritus for a short while, but is invariably followed with a return of the desire to scratch. Unpleasant side actions, a brevity of alleviation, and failure of the remedy in certain cases have been encountered during therapy with this drug. Intravenous novocain, according to the method of State and Wangensteen,[1] has been tried, but likewise is only temporarily effective. Sundry sedatives, hypnotics, and analgesics are without prolonged benefit, and in certain instances expose the recipient to the hazard of addiction.

If, in these patients, the abnormal retention of bile salts is associated with or is the cause of the pruritus, then relief from the itching may be anticipated if it is possible to reduce this concentration in the circulation. A rational therapeutic approach, therefore, appeared to be the development of some method for the reduction of the serum bile salt level. Reasonable alterations in the diet offered little hope of reducing the serum bile salt concentration, since these people should receive a high protein intake for the therapy of the chronic hepatic disease.[2] Since, however, from the total quantity of bile salts secreted each twenty-four hours, about 90 per cent is reabsorbed from the intestinal tract, recirculated through the liver, and then re-eliminated in the bile, a preenteric deviation of bile should theoretically eventually reduce the serum bile salt level.[3] These conjectures have been translated into surgical procedures applied to clinical material, and it has been found that intermittent external biliary drainage suffices to attain and maintain prompt and virtually complete relief from this type of pruritus.

Seven operations have been performed on six patients without fatality. In one, cholecystostomy proved unsatisfactory, for after a week or two of postoperative relief from the pruritus, this symptom recurred when the drainage decreased virtually to zero. Three patients had a cholecystostomy and catheterization of the common bile duct via the cystic duct. In these cases there has been some difficulty in reinserting a catheter through this opening when it became necessary to replace this tube about six to eight weeks after surgery. Cholecystostomy and drainage of the common bile duct with a T tube has been the operative procedure three times. This plan has been consistently effective; however, since the common bile duct is undilated in this type of case,

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a rather small caliber T tube, size 10 or 12 French, must be available, and may pose some minor technical difficulty.

All analyses for bile salt content were carried out according to the method of Josephson[4] for blood, and Reinhold and Wilson[5] for bile.

Table I presents data relative to the blood levels preoperatively, and then the reduction in these values following a postoperative period of external biliary drainage. In Table II, the blood level for bile salts is charted pre- and postoperatively. A reduction can be noted following the phase of external biliary drainage. During the period of this study there is also demonstrated a definite downward trend in the percentage of bile salt in the biliary secretions, as one would predict after interposing a shunt into the enterohepatic circulation of this component.

TABLE I. BILE ACIDS CONCENTRATION

| | IN BLOOD | | | | | | IN BILE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PREOPERATIVE (MG. %) | | | POSTOPERATIVE (MG. %) | | | OPERATIVE | | POSTOPERATIVE | |
| | DATE | PATIENT | CONTROL | DATE | PATIENT | CONTROL | DATE | MG. % | DATE | MG. % |
| R. B. | 2/ 4/45 | 9.2 | 0.76 | 2/18/45 | 2.30 | 0.45 | 2/4/45 | 18.5 | 2/18/45 | 3.5 |
| A. R. | 9/27/45 | 3.2 | 1.20 | 11/ 5/45 | 0.65 | 0.71 | | | | |

TABLE II. LEVEL FOR BILE SALTS IN PATIENT A. R. CHARTED PREOPERATIVELY AND POSTOPERATIVELY

| DATE | VOLUME (C.C.) | BILE ACIDS CONCENTRATION IN BILE (MG. %) | BILE ACIDS CONCENTRATION IN BLOOD | |
|---|---|---|---|---|
| | | | PATIENT (MG. %) | CONTROL (MG. %) |
| 2/ 4/46 | | | 1.10 | 0.80 |
| 2/15/46 | 215 | 12.50 | (Preoperative) | |
| 2/16/46 | 468 | 15.98 | | |
| 2/17/46 | 480 | 12.00 | | |
| 2/18/46 | 445 | 9.00 | | |
| 2/18/46 | | | 0.82 | 0.45 |
| 2/19/46 | 625 | 7.70 | (Postoperative) | |
| 2/20/46 | 565 | 4.50 | | |

CASE REPORT

A. R. (U. H. No. 755372) was first admitted May 15, 1945. She had been bothered persistently for eight years by generalized pruritus of varying intensity. Through the years her skin had thickened and become darker, but, so far as she knew, had never been visibly jaundiced. These facts were confirmed in a physical examination, which revealed an enlarged, slightly tender liver, but was otherwise essentially noncontributory. Liver function studies suggested definite hepatic damage. Thirty per cent of bromsulphalein (5 mg. per kilo.) was retained at forty-five minutes. An hyperurobilinogenuria was present upon repeated examinations. The prothrombin time, twice the control, returned to normal after 6.4 mg. of vitamin K parenterally. The serum bilirubin was 1.0 mg. per cent at 1 minute with a total of 1.9 mg. per cent. Peritoneoscopy at this time indicated the characteristically hobnailed liver of Laënnec's cirrhosis. A rather severe reaction followed this procedure, but the patient was eventually discharged and advised to consider submitting to an operative procedure for the control of her pruritus. She returned and a cholecystostomy and catheter choledochostomy via the cystic duct was carried out Oct. 9, 1945. The enlarged, nodularly fibrotic liver was biopsied and microscopically identified as cirrhotic. Her serum bile salt level declined from a preoperative value of 3.2 mg. per cent with a control of 1.2 mg. per cent to a postoperative value of 0.65 mg. per cent and a

control of 0.71 mg. per cent. Clinically, the relief from pruritus was virtually complete, and to the patient, wholly satisfactory. Unfortunately, the choledochostomy catheter became untethered while she was home and was not replaced for so long an interval that the fistula closed over. Within a few weeks the itching had returned in such intensity that she requested operative relief. On Feb. 14, 1946, a T tube was placed in the common duct and with the development again of external biliary drainage, the itching urge was controlled. Convalescence from both procedures was without event, and the patient has remained well and free from distress by opening the external limb of the T tube for a few hours daily. The consistent decline in the bile salt content (Table II) of the bile drainage, analyzed daily postoperatively, supports the thesis of an enterohepatic circulation, for with the external shunt permitting less bile salts to enter the intestine diurnally, each following day's value is consecutively reduced.

## DISCUSSION

Small quantities of bile salts have been given orally upon three occasions to patients in this series during the time each had an external biliary fistula. Pruritus promptly returned and then disappeared with maintenance of the external biliary drainage.

In no instance has it proved necessary to develop a complete or even high grade deviation of the bile in order to provide satisfactory surcease from the itching. Circuiting the bile to the outside for short intervals daily has sufficed to keep these persons comfortable. In all patients, chronic hepatic disease has been the preoperative diagnosis, and this has been confirmed by the pathologic report of liver biopsies secured during the surgical procedure. It should be emphasized that pruritus associated with acute hepatitis is so frequently a self-limited disease, that any surgical procedure for its relief would seem unwarranted.

The elevation of the serum bile salt level in these patients with chronic hepatic disease has been quite independent of any relationship, direct or reciprocal, to pigment retention. Jaundice, therefore, cannot be quantitatively assayed and then interpreted as a reflection of the need for this procedure. Indeed, many of the patients studied have had virtually no bilirubinemia. Jaundice per se, so convincingly demonstrated in those instances of hemolytic origin, cannot evoke pruritus. This differential retention of bile salts in the serum exemplifies another instance of one altered hepatic function with many others remaining seemingly unimpaired.

## SUMMARY

Intermittent external biliary drainage has been employed with success for the relief of pruritus occurring in certain patients with chronic hepatitis or cirrhosis.

## REFERENCES

1. State, David, and Wangensteen, Owen H.: The Use of Procaine Intravenously in the Treatment of Delayed Serum Sickness and Other States of Hypersensitiveness, J. A. M. A. **130:** 990-995, 1946.
2. Whipple, G. H.: The Origin and Significance of the Constituents of the Bile, Physiol. Rev. **2:** 440-459, 1922.
3. Foster, M. G., Hooper, C. W., and Whipple, G. H.: Metabolism of Bile Acids, J. Biol. Chem. **38:** 355-420, 1919.
4. Josephson, B.: The Determination of Cholic Acids in Blood, J. Biochem., Part II **29:** 1519, 1935.
5. Reinhold, John, and Wilson, Wright: The Determination of Cholic Acids in Bile, J. Biol. Chem. **96:** 637-646, 1932.

# SPLENECTOMY

## An Analysis of Thirty-Eight Cases

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AT THE Charity Hospital, New Orleans, La., during the period from Jan. 1, 1939 through 1945, there were thirty-eight splenectomies performed. This number does not include those done for trauma, neither does it include those done during the course of esophagectomy or total gastrectomy. Eleven of these splenectomies were done for congenital hemolytic anemia, one for acquired hemolytic anemia, four for idiopathic thrombocytopenic purpura, ten for Banti's syndrome, one for splenic neutropenia, six for sickle-cell anemia, one for splenic torsion, one for aleucemic leucemia, and three for "unknown etiology." For various reasons, splenectomy was not done on all patients with a final diagnosis of the various conditions mentioned here. For instance, during this period there were thirty-seven patients with a final diagnosis of congenital hemolytic anemia, forty-two of acquired hemolytic anemia, twenty-four with idiopathic thrombocytopenic purpura, seventy-seven with Banti's syndrome, three with splenic neutropenia, two hundred sixty-seven with sickle-cell anemia, two with splenic torsion, and fifteen with aleucemic leucemia.

The relative rarity of these diseases is recognized when one realizes that during this time period there was a total of 361,382 admissions.

The operation of splenectomy is said to enjoy considerable antiquity. Rational splenectomy, apart from that predicated by acute surgical conditions, especially traumatic cases, was not established by empirical experiment until the early part of the twentieth century. The pioneer work of Barcroft, McNee, Lord Dawson, and Krumbhaar in creating sound fundamental concepts of physiologic splenic functions has been supplemented by the controlled studies of pathologic, splenic diseases by the hematologists Kaznelson, Frank, Dameshek, Doan, Wiseman, and others.

### FUNCTIONS OF THE SPLEEN

1. The spleen as an hemopoietic organ. In the embryo, the spleen, along with the liver, assumes the chief role of the formation of blood cells. After birth, this function is taken over by the red bone marrow. In certain disease states involving the hematopoietic system of the adult, the spleen is capable of resuming its embryologic function. In adults, the spleen normally supplies lymphocytes and monocytes to the circulation. The large reticuloendothelial cells of the spleen are thought by some to play a role in the metabolism of fat, especially cholesterol. The reticuloendothelial cells also play a role in the production of antibodies for the body.

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2. A most popular conception is that the spleen destroys effete blood cells of the circulation, yet there is no potent evidence to uphold this view. Blood drawn from the splenic artery and vein fails to show any difference in the urobilinogen content, which would be the case if active destruction took place in the spleen. If the red cells were destroyed in the spleen, there would be an increase in the iron content as revealed by special stains. This has not been shown to be the case. Phagocytosis of the red and white cells by the reticuloendothelial cells has been demonstrated, but only to a minor degree, and not sufficiently to make this a great function of the spleen. It is thought that excessive destruction of platelets by the spleen is the responsible factor in thrombocytopenic purpura, but no definite evidence of this has been found in the spleens removed from patients with this disease. In congenital hemolytic anemia the fragility of the red blood cells is increased and spherocytosis appears. While most patients become completely asymptomatic following splenectomy, increased fragility and spherocytosis usually persist.

3. The great vascularity of the spleen is well known. By virtue of its rhythmic contractions it regulates the blood flow to the gastrointestinal tract during digestion. In extreme oxygen want, as seen in severe anemia, at high altitudes, and in carbon-monoxide poisoning, the spleen pours out into the circulation its large reserve of red cells.

4. According to Naegele, the spleen in some unknown way possesses hormonal action. He suggested that some substance is liberated by the spleen which has a hemming action on the bone marrow. Removal of the spleen permits overactivity of the bone marrow and an outpouring of immature red and white cells and platelets into the peripheral circulation. This may be the mechanism for improvement following splenectomy in congenital hemolytic anemia, thrombocytopenic purpura, Doan's neutropenia, and even splenic anemia. This is further evidenced by the fact that histologic examination of the spleen throws no light on the local mechanism as an etiologic factor.

### CONGENITAL HEMOLYTIC JAUNDICE

Congenital hemolytic anemia is characterized by the following: (a) A severe anemia, jaundice, and microspherocytosis. Reticulocytes are increased in number and nucleated red blood cells are often found in the peripheral circulation. There is usually a leucocytosis. (b) The fragility test is the most important laboratory procedure in this disease. Normally, hemolysis of red blood cells begins in a salt concentration of 0.42. In congenital hemolytic jaundice the hemolysis begins at higher concentrations. (c) The icterus index is elevated and the van den Bergh test gives an indirect reaction. (d) There is an increased amount of urobilinogen in the urine and no bilirubin present, hence the term "acholuric jaundice." (e) Bone marrow studies usually reveal a preponderance of the erythroid series over the myeloid. The only abnormal type of cell present is the spherocyte.

Following splenectomy in this disease, the preoperative fragility index does not change and spherocytes may still be found in the peripheral blood. Gallstones of the calcium bilirubinate type may be found in 30 to 40 per cent

of patients.[1] From time to time the patient suffering with this disease may suffer hemolytic crisis. At times, because of the severity of the crisis, it may become necessary to operate during the crisis. When this becomes necessary, large volumes of blood must be on hand to support the patient.

Sharpe and Tollman[2] report that splenectomy has been performed in refractory hemolytic anemia in adults without avail. This disease, clinically, is similar to congenital hemolytic anemia; but that the anemia is macrocytic instead of microspherocytic, there is no increase in fragility of the red blood cells and there is usually a leucopenia instead of a normal or elevated white cell count.

Strausky and Regala[3] have shown that in patients with atypical, chronic, familial, hemolytic jaundice; i.e., absence of both spherocytosis and increased fragility of red blood cells, splenectomy may be followed by persistent anemia, jaundice, and all the symptoms of increased destruction of red blood cells. This may be explained on the basis that there may be present in the spleen a substance that is responsible for the maturation and denucleation of the red cells in the bone marrow. This would strike a note of warning against the advisability of the indiscriminate performance of splenectomy.

Of the eleven patients on whom splenectomy was done for congenital hemolytic anemia, nine were white and two colored; seven were male and four were female, and the ages ranged between 6 months and 52 years. Splenectomy was done before the third decade of life on six of these patients.

According to the charts, three patients gave a definite history of anemic crisis. The symptoms, signs, and laboratory findings were classical in all of the patients. The recorded incidence of cholelithiasis was lower than in most other reported series, occurring in only one of the patients.

Splenectomy was done in all of these cases with the patient under general anesthesia, after preoperative preparation with blood transfusions. The pathologic diagnosis on all of the removed specimens was "compatible with congenital hemolytic anemia." The available follow-up records, ranging over a period from three months to three years, revealed that the results were excellent in eight of the patients. One of the patients showed only slight improvement three months after splenectomy; the hematologist, after postoperative survey, suggested that perhaps accessory spleens had been left behind.

There were two deaths. One patient died immediately postoperatively from peritonitis and pneumonitis. The other patient, several months post-splenectomy, developed a polycythemia and, two years following operation, died of bronchopneumonia.

### ACQUIRED HEMOLYTIC ANEMIA

In this series there was one patient with a final diagnosis of acquired congenital hemolytic anemia. It seems to be the consensus of opinion that this diagnosis is made when congenital hemolytic anemia remains dormant or goes unrecognized until adulthood.

This patient was a white man who had all of the classical symptoms, signs, and laboratory findings of congenital hemolytic anemia. The patient died on the first postoperative day of hemorrhage from a slipped splenic pedicle.

### IDIOPATHIC THROMBOCYTOPENIC PURPURA

The diagnosis of idiopathic thrombocytopenic purpura is not always easy. It is important that all forms of symptomatic purpura and various blood dyscrasias be excluded before splenectomy is done.

The following findings are of extreme value in the diagnosis of this condition: (a) One of the most important procedures is determining the bleeding time, which may be done by puncturing the finger or ear and collecting drops of blood every few seconds until the flow stops normally; this stops in from three to five minutes. In idiopathic purpura hemorrhagica, the bleeding time is considerably prolonged. (b) The coagulation time, using the capillary tube method, is normal in idiopathic purpura, whereas it is greatly prolonged in hemophilia. (c) The clot retraction time in normal individuals reveals beginning retraction in one hour and completion of the retraction in twenty-four hours; whereas, in idiopathic purpura, the clot retraction time is greatly increased and may even fail to retract. (d) The blood platelet count may fall from the normal of 250,000 to 350,000 to as low as 15,000 to 25,000. (e) Nonprotein-nitrogen determination of the blood may eliminate uremia as a possible cause of symptomatic purpura.

Many feel that it is necessary for sternal marrow studies to show a megakaryocytic hyperplasia in order to forecast a good prognosis following splenectomy. Pernokis[4] is not in accord with this conception. In none of his patients with exceptionally good results following splenectomy did he find an increase in the megakaryocytes by sternal puncture. He does, however, favor bone marrow study to exclude two conditions with which idiopathic thrombocytopenic purpura may be confounded; namely, aplastic anemia and aleucemic leucemia.

Splenectomy is universally advocated for the successful treatment of idiopathic thrombocytopenic purpura. Polowe[5] advocates immediate splenectomy even when this condition exists with pregnancy, and reports a successful case, the splenectomy being done during the eighth month of pregnancy.

In this series there were four splenectomies done for idiopathic thrombocytopenic purpura. All occurred in the white race. Three patients were female and one was male. The ages ranged from 3 years to 18 years. It was recorded that the spleen was palpable in one case, not palpable in two cases and, in the fourth case, no mention was made concerning this finding. Classical symptoms, signs, and laboratory findings were otherwise present.

General anesthesia was employed in these patients and all received blood transfusions preoperatively, during the operation, and postoperatively. The pathologist's report was "spleen compatible with thrombocytopenic purpura."

From immediately postoperative to four years after splenectomy, the results were excellent in three patients. One patient, who was in extremely poor shape when finally transferred to the surgical service, died as the result of "continuous oozing from the splenic bed."

### BANTI'S SYNDROME

Banti, in 1883, first called attention to this syndrome. Subsequently, he described the disease running its course in three definite stages: (1) the anemic

phase, with splenomegaly, asthenia, and occasional hemorrhage; (2) the transitional stage, with oliguria, urobilinuria, hepatomegaly, brown discoloration of the skin, and increasing gastrointestinal bleeding; and (3) an ascitic stage, with atrophy of the liver, subicteric sclerae, hemorrhage from the mucous membranes, and death from hemorrhage or liver insufficiency.[6]

According to Blakemore and Lord,[7] it is necessary to determine the site of portal obstruction before rational therapy can be instituted. One can predict, on the basis of liver function chemistry, whether the portal hypertension is due to intrahepatic (portal cirrhosis), or extrahepatic portal bed block. If the liver is the site of the portal block, i.e., portal cirrhosis as manifested by deficient liver function, splenectomy alone will not effect a cure. In this type of case it is necessary to perform a portocaval shunt in addition to the splenectomy. They describe in detail their technique, using the vitalium tube, nonsuture method of anastomosis between the portal and caval systems.

Even when the block is extrahepatic but proximal to the entrance of the coronary vein into the portal system, splenectomy alone will not effect a cure. It is only in those cases in which the obstruction is distal to the entrance of the coronary vein into the splenic vein that splenectomy alone will give a satisfactory result with relief of hematemesis, anemia, leucopenia, and thrombocytopenia.

These authors use manometric readings made at various points of the portal system to determine the site of obstruction. For example, in a patient with congestive splenomegaly in which the superior mesenteric pressure is normal, the splenic vein pressure elevated, but the coronary vein pressure approximately normal, splenectomy only would be indicated. A normal reading from the superior mesenteric vein and an elevated reading from a branch of the coronary vein would make mandatory splenorenal anastomosis following splenectomy.

It is hoped that these recent concepts of Banti's disease might alter the poor results that have been obtained in the past.

In a discussion of Banti's disease it is interesting to call attention to the Cruveilhier-Baumgarten syndrome. Bruno[8] states that, up to 1942, sixty-six patients with this condition have been reported in the literature. This syndrome is characterized by the clinical picture of portal hypertension, evidence of excessive umbilical circulation, and the presence of a loud abdominal murmur and thrill. The murmur and thrill are due to the rich anastomosis between umbilical or para-umbilical veins and the thoracoabdominal veins in attempting to establish a collateral circulation.

Of the ten patients on whom splenectomies were done following diagnosis of Banti's disease, six were white and four were colored; seven were male and three female; and the ages ranged from 8 to 64 years. The findings were variable. All suffered with anemia which was secondary to bleeding hemorrhoids, esophageal varices, or lower gastrointestinal pathology, possibly purpuric in character: the spleen was enlarged in all patients, the liver was mentioned as having been enlarged in five, and ascites was listed in three.

The pathologist's report of the removed specimens was "uniformly splenic fibrosis and congestion." Two patients may be classified as obtaining fairly

good results from splenectomy. Examination of one of these patients two years after operation revealed that he had gained weight and that he was no longer anemic. The other patient, examined approximately two years after operation, showed a marked improvement in his anemia, the red blood cell count having risen to 4,450,000 from a preoperative count of 960,000.

Four patients showed no improvement whatsoever over their preoperative status.

Four patients died; one, two weeks after operation, with postmortem examination revealing retroperitoneal reticulum cell sarcoma; another, one year after operation, from gastrointestinal hemorrhage; the third, the same day of operation, as the result of a slipped splenic pedicle; and the cause of death was not indicated on the chart of the fourth patient.

It is possible that the two patients in this series classified as showing improvement following splenectomy may fall in that group of patients described by Blakemore and Lord as being amenable to splenectomy alone.

### DOAN'S NEUTROPENIA

Wiseman and Doan,[9] in 1942, following a preliminary report in 1939, introduced a newly recognized syndrome characterized by marked neutropenia and splenomegaly. They feel that this syndrome is comparable to congenital hemolytic icterus and thrombocytopenic purpura. In congenital hemolytic icterus there occurs excessive erythrocyte destruction, in thrombocytopenic purpura an excessive platelet destruction, while in splenic neutropenia there exists an excessive destruction of white blood cells. It is most interesting that the selective action of the clasmatocyte of the spleen is capable of producing three distinct clinical entities.

The salient diagnostic features are splenomegaly, purpura (depending on the degree of associated thrombocytopenia), oral ulceration (depending upon the acuteness and severity of the neutropenia), and, occasionally, mild icterus (depending on the degree of associated hemolytic anemia).

The bone marrow shows hyperplasia of the myeloid series and, if hemolytic anemia is pronounced, of the erythroid series. The marrow is not leucemic and no abnormal cells are present.

The blood shows marked specific neutropenia. If anemia is present, it is macrocytic and hyperchromic in type. If anemia is definite, reticulocytosis is present, and there is an increased, indirect, van den Bergh reaction. The thrombocytopenia is variable.

Experience, so far, shows that splenectomy is specific therapy for this disease in that the patients are restored to a normal hemolytopoietic equilibrium.

One splenectomy in this series was done for splenic neutropenia. The subject was a 23-year-old, white man with splenomegaly, leucopenia, hemolytic anemia, and thrombocytopenia. The bone marrow was hyperplastic for the granulocytic series and the patient had ulcers of both legs. The preoperative laboratory findings were: red blood cells, 3,900,000; white blood cells, 1,100; polymorphonuclears, 61 per cent; platelets, 100,000. The laboratory follow-up one and one-half years following splenectomy showed decided improvement:

red blood cells, 5,100,000; white blood cells, 8,520; polymorphonuclears, 55 per cent; and platelets, 219,600. The general condition of the patient was also markedly improved.

### SICKLE-CELL ANEMIA

Sickle-cell anemia occurs only in Negroes. Women are affected more than men. Five to ten per cent of all Negroes possess sickling trait, but only 10 per cent showing a sicklemia develop an associated anemia.

The findings are: weakness, fatigue, anorexia, abdominal pain, icterus of sclerae, and pain in left upper quadrant from splenic infarcts. Arthritic manifestations and ulcers of the leg are not uncommon. Shortly after a crisis, examination reveals an icteric tinge to the sclerae, pallor of mucous membranes, enlargement of the liver and spleen, enlargement of the heart with hemic murmurs, tenderness and spasticity of the abdominal muscles, elevated temperature, and increased pulse and respiratory rate. Between crises, symptoms are mild and there may be no splenic enlargement.

Examination of the blood reveals the characteristic sickling of the red blood cells, leucocytosis, and erythroblastic activity. In the chronic form in children, the bones show a thickened marrow space with thinning of the cortex.

The value of splenectomy in this condition is doubted by most authorities, because lymph nodes and other reticuloendothelial tissue may carry on the phagocytic function of the spleen even if it is conceded that the spleen is responsible for deterioration of the red blood cells.[10]

The pediatric and surgical units at Charity Hospital agreed to try splenectomy on some of these patients to determine what could be accomplished. Follow-up statistics over a two-year period on the six patients treated by splenectomy in this series show that the results are anything but encouraging.

All of these patients were of the colored race, and four were male. The ages varied from 22 months to 7 years.

### TORSION OF THE SPLEEN

Sheppard,[11] in 1944, made note that there were twenty-five recorded cases of splenic torsion. He reported upon one of his own patients splenectomized with a successful outcome.

Abdominal pain, vomiting, signs of shock, adynamic ileus, and signs of peritonitis have been outstanding features of this condition. The clinical picture may closely resemble intestinal obstruction.

In the present series there was one patient. This patient was a white woman, 24 years old. On admission, she presented severe pain, vomiting, and a large, tender mass in the abdomen. A preoperative diagnosis of twisted ovarian cyst was made. At operation, the spleen was found to be enlarged and twisted three times upon itself. Splenectomy was done, and the patient made a remarkable recovery. The pathologist reported thrombosis of hilar vessels with massive splenic infarction.

### ALEUCEMIC LEUCEMIA

A colored man, age 66, was admitted with the following findings: loss of weight; enlargement of the abdomen; shortness of breath; a hard mass palpable

in the left, upper, abdominal quadrant; red blood cells, 4,000,000; white blood cells, 10,350; lymphocytes, 82 per cent.

Splenectomy was done without any idea of what the diagnosis was, but with the hope that removal of this "mass" might help the patient. Two months following splenectomy, the patient returned for a check-up and stated that he actually felt better, having been relieved of the dyspnea and the heaviness in the upper abdomen. There is no further follow-up on this patient. The pathologist's report was "lymphatic leucemia."

I feel certain that, had the diagnosis been known before operation, splenectomy would have never been done. There is complete agreement that splenectomy is of no value in the leucemias.

### UNKNOWN ETIOLOGY

There were three patients in the series that had splenectomy and on whom a final diagnosis could not be made.

One patient, a white woman, age 52, came into the hospital complaining of epigastric burning and abdominal distention. X-ray revealed a calcified body in the left, upper, abdominal quadrant. Exploration was done for the possibility of a calcified spleen and partial intestinal obstruction. In the operative note it was mentioned that the spleen was enlarged and removed. The report of the pathologist revealed spleen engorged with red blood cells. The patient was discharged still complaining of epigastric burning. The chart showed no further follow-up of the patient.

The second patient, a white woman, aged 56, was admitted with pain in the back, tenderness, and pain in the left, upper quadrant. The spleen was enlarged and splenectomy was done under a preoperative diagnosis of splenectomy of unknown etiology. At operation, calcification of the splenic artery was noted, the spleen was twice the normal size, and several calcified lymph nodes were found in the hilum. The pathologist's report was "splenic fibrosis." The patient was discharged free from pain, and no further follow-up was recorded on the chart.

The last patient, a white woman, age 38, had splenectomy because of pain in the abdomen and legs and a mass in the left, upper quadrant. At operation the spleen was of normal size and there were no areas of calcification noted. The pathologist's report was "chronic splenitis." The patient was discharged unimproved.

It seems that, in the last three cases, splenectomy was done for want of something better to do. It is doubtful that any of the patients ultimately noticed any relief.

### OTHER INDICATIONS FOR SPLENECTOMY

Surveying the literature, one finds reported instances of splenectomy with apparently good results for various splenopathic states.

According to Paul,[12] cysts of the spleen are very rare. He classifies cysts of the spleen as follows:

I. Hydatid cysts.

II. Cysts associated with polycystic disease of the kidneys.

III. Single cysts:
  (a) dermoid
  (b) epidermoid
  (c) serous and blood cysts, devoid of epithelial lining.

IV. Multiple serous cysts.

The symptoms in most of these patients are attributable to pressure. The treatment of choice is splenectomy.

Hausmann and Gaarde[13] report one case of splenectomy for reticulum cell sarcoma. The patient ultimately expired because of recurrence. Malignancies of the spleen may be classified as follows: (1) fibrosarcoma; (2) endothelioma; (3) lymphosarcoma and Hodgkin's granuloma; and (4) reticuloendothelial sarcoma. The authors feel that splenectomy is justified if, at exploratory laparotomy, the spleen is the sole focus of the pathologic process. They mention that patients are alive at the end of four to eight years.

Steinberg[14] advises splenectomy for Felty's syndrome after conservative measures have failed. This condition was first described by Felty in 1924. It is characterized by atrophic arthritis, fever, secondary anemia, leucopenia, splenomegaly, and tachycardia. Splenectomy is deemed rational because the bone marrow shows hyperplasia and it is believed, therefore, that the spleen stands in the way of blood elements being present in adequate quantities in the blood stream.

### SOME CONTRAINDICATIONS

Reich and Rumsey[15] caution against splenectomy in a condition they term "agnogenic myeloid metaplasia of the spleen." This condition is characterized by splenic enlargement and the presence of immature red and white blood cells in the blood. It is often erroneously diagnosed as chronic myelogenous leucemia, splenic anemia, erythroblastosis, or Hodgkin's disease. Frequently, the picture is so confusing that a splenectomy is performed with unfavorable results.

In this condition, myeloid metaplasia of the spleen is present and the authors present five cases which show that depression of this focus of myeloid metaplasia by splenectomy definitely places the patient on a downhill course.

This condition is most easily confused with Banti's disease and atypical leucemia. However, Banti's disease does not show both immature red and white blood cells in the peripheral blood; and sternal puncture will rule out leucemia, if no leucemic infiltration is observed in the marrow of the patients.

Carpenter,[16] in his article, concludes that splenectomy is absolutely contraindicated for Cooley's disease and polycythemia rubra vera.

### SUMMARY AND CONCLUSIONS

1. An analysis of thirty-eight splenectomies done at the Charity Hospital, New Orleans, La., during the period from Jan. 1, 1939 through 1945, is presented.

2. It can be concluded that splenectomy is definitely indicated for congenital hemolytic anemia, idiopathic thrombocytopenic purpura, splenic neutropenia, and splenic torsion. Before splenectomy is done in cases of so-called

Banti's disease, the cases should be evaluated very carefully as recommended by Whipple, and Blakemore, and Lord.[6, 7]

3. Splenectomy was found to be of little or no value in the patients with sickle-cell anemia, aleucemic leucemia, and those splenectomized under the diagnosis of "splenomegaly of unknown origin."

4. Other conditions for which splenectomy has been done with good results are discussed.

5. Some of the contraindications are discussed.

## REFERENCES


1. Cole, W. H.: Indications for Splenectomy, Mississippi Doctor **20**: 63, 1942.
2. Sharpe, J. C., and Tollman, J. P.: Refractory Hemolytic Anemia, Arch. Int. Med. **70**: 11, 1942.
3. Stransky, E., and Regala, A. C.: Erythroblastic Anemia Following Splenectomy in Cases of Chronic Familial Hemolytic Anemia, Am. J. Dis. Child. **63**: 859, 1942.
4. Pernokis, E. W.: Splenectomy in Medical Practice, J. A. M. A. **118**: 865, 1942.
5. Polowe, D.: Splenectomy in Pregnancy Complicated by Thrombocytopenic Purpura, J. A. M. A. **124**: 771, 1944.
6. Whipple, Allen O.: The Problem of Portal Hypertension in Relation to the Hepatosplenopathies, Ann. Surg. **122**: 449, 1945.
7. Blakemore, A. H., and Lord, J. W., Jr.: The Technic of Using Vitallium Tubes in Establishing Portacaval Shunts for Portal Hypertension, Ann. Surg. **122**: 476, 1945.
8. Bruno, F. E.: The Cruveilhier-Baumgarten Syndrome, New Orleans M. and S. J. **95**: 339, 1942.
9. Wiseman, B. K., and Doan, C. A.: Primary Splenic Neutropenia, Ann. Int. Med. **16**: 1097, 1942.
10. Mitchell-Nelson, Textbook of Pediatrics, Philadelphia, 1945, W. B. Saunders Co.
11. Sheppard, M. D.: Torsion of the Spleen, Brit. J. Surg. **31**: 97, 1944.
12. Paul, M.: Cysts of the Spleen, Brit. J. Surg. **30**: 336, 1942.
13. Hausmann, P. F., and Gaarde, F. W.: Malignant Neoplasms of the Spleen, SURGERY **14**: 246, 1943.
14. Steinberg, C. L.: The value of Splenectomy in Felty's Syndrome, Ann. Int. Med. **17**: 26, 1942.
15. Reich, C., and Rumsey, W.: Agnogenic Myeloid Metaplasia of the Spleen, J. A. M. A. **118**: 1200, 1942.
16. Carpenter, G.: Medical Indications for Splenectomy, Arizona Med. **1**: 313, 1944.

# A FATAL HEMOLYTIC REACTION FOLLOWING TRANSURETHRAL RESECTION OF THE PROSTATE GLAND

## A Discussion of Its Prevention and Treatment

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EVERY urologist who strives to resect the prostate gland transurethrally down to the surgical capsule knows that the operation is sometimes followed by uremia which is difficult to explain. Postoperative uremia may follow such evident causes as acute pyelonephritis, prolonged severe hypotension (anesthesia, hemorrhage, or surgical shock); reactions to the transfusion of incompatible blood or to the administration of sulfonamides; or trauma to the ureteral orifices with resultant hydronephrosis. However, cases occur in which these factors can be excluded.

Since the type of uremia under discussion seems to occur most often when considerable blood has been lost during or after operation, one is tempted to attribute the azotemia to spasm of the renal blood vessels. Phillips and coworkers have demonstrated an almost complete cessation of glomerular blood flow during severe hemorrhage in dogs, even though the blood pressure is maintained above shock levels. Van Slyke has described a similar situation in surgical shock, and has pointed out that impairment of renal function may become irreversible if the hypotension lasts for some hours. Page and Corcoran observed oliguria and azotemia in dogs after severe hemorrhage even with prompt replacement of the lost blood. They have attributed the renal impairment to vasospasm mediated by some humoral mechanism, since it occurs even if the kidneys are denervated first. Bingham has suggested that bilateral renal cortical necrosis may be due to renal ischemia from vasoconstriction.

While these ideas explain some features of the obscure uremia which may follow transurethral resection, they do not account for the mild, nonobstructive jaundice which usually accompanies it, nor for the fact that an anemia out of all proportion to the amount of blood lost by hemorrhage is often demonstrable as early as twenty-four hours after operation.

The explanation of these phenomena is probably to be found in the suggestion recently made by Emmett to the effect that the sterile water used as an irrigating fluid during transurethral resection may enter the prostatic veins and produce hemolysis, thus damaging the kidneys exactly as does a transfusion with incompatible blood. Foley has independently had the same idea. He saw red spurts of urine coming from the ureteral orifices during transurethral resection in a patient with kidneys known to have been normal before operation, and found a high concentration of free hemoglobin in the plasma after operation, thus proving that hemolysis had occurred.

It is well known that hemolytic reactions are followed by jaundice, and Duesberg has detected a rise in serum bilirubin within thirty minutes after the

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intravenous injection of a solution of hemoglobin. Moreover, the destruction of the patient's red cells by hemolysis would account for the disproportionate severity of the anemia already mentioned, and the explanation of other complications sometimes seen after transurethral resection of the prostate would be clarified; the escape of an unknown, but probably large, amount of fluid into the circulation might cause an unexpected cardiac decompensation; the fluid could easily carry with it virulent bacteria from the prostate and produce an acute pyelonephritis or septicemia.

The more frequent occurrence of these uremias in patients with unusually large losses of blood is easily explained on the basis of hemolysis. Brisk hemorrhage requires the use of larger quantities of irrigating fluid at higher pressures to permit the operator to see clearly, and the operation is necessarily prolonged. Thus, conditions are favorable for the occurrence of hemolysis.

Since becoming aware of the possibility of hemolysis from irrigating fluid, we have had the hemoglobin of the plasma estimated either quantitatively or qualitatively, sometimes before, and always after, transurethral resection. Free hemoglobin has been found in almost every instance in which water was used as an irrigating medium, although most of the patients have exhibited no ill effects. Control observations are being made and will be the subject of a future report.

In the meantime, the occurrence of a fatality apparently due to hemolysis during transurethral resection seems sufficiently interesting to warrant a preliminary report.

## CASE REPORT

B. K., aged 68 years, was admitted to St. Barnabas Hospital on May 26, 1946, because of symptoms of prostatism which had recurred after a prostatic operation done elsewhere in 1940. General condition was good. The blood pressure was 160/90; the heart was slightly enlarged to the left, and the lungs were normal. The prostate gland was moderately enlarged and rather firm in consistency. The residual urine measured 50 c.c. and contained a nonhemolytic streptococcus. Examination of the morphology of the blood and of the urine yielded normal results. The urea nitrogen was 20 mg. per cent, and the acid and alkaline phosphatase levels in the serum were 3.6 and 9 King-Armstrong units.

On May 28, 1946, one of us (E. A. W.) did a transurethral resection of the prostate under spinal anesthesia supplemented during the latter part of the operation by pentothal sodium. Fifty-eight grams of tissue were removed with a blood loss, estimated by the method of Conger and Nesbit, at 600 c.c. Because of this, and despite the fact that the systolic blood pressure did not fall below 120 mm. of mercury, 500 c.c. of human plasma were given intravenously; the patient was placed in an oxygen tent immediately after operation because of what was thought to be a toxic reaction from pentothal sodium. He remained drowsy and restless all day. That evening, the plasma was found to be dark red in color, although no quantitative estimate of the free hemoglobin was made. Five per cent sodium bicarbonate, 500 c.c., was given intravenously.

The fluid intake during the day of operation totaled 2,000 (exclusive of the plasma) and the urine output 550 c.c. The blood pressure remained above 120.

On the morning after operation the patient was nauseated; the urea nitrogen was 54 mg. per cent, and the hemoglobin had fallen from 87 to 50 per cent (Sahli), with a red blood count of 2,630,000. Slight jaundice was noted, but no serum bilirubin determination could be made because of the hemoglobinemia, which was still considerable. The fluid intake on the first postoperative day was 2,000, and the urine output was 825 c.c.

On the second postoperative day the hemoglobinemia had disappeared and the plasma was straw colored, but the urea nitrogen was 70 and the urine output, with an intake of 2,250, was 440 c.c. Five per cent sodium bicarbonate was again given, and was followed by 500 c.c. of matched, citrated whole blood (the first transfusion).

The oliguria continued, and fluids were administered conservatively. By June 4 urea nitrogen was 109, the creatinin was 5.2, the $CO_2$ was 55, and the plasma proteins were 5.8. He had continued apathetic and had developed moderate generalized edema; the blood pressure was 190/102. Peritoneal lavage as described by Fine and associates was instituted on June 5, and transfusion was given a second time with citrated blood, preceded by 5 per cent sodium bicarbonate. Penicillin was given intramuscularly and streptomycin was added to the lavage fluid. Auricular fibrillation appeared and digitalization was done by another doctor. By June 9, the urea nitrogen had fallen to 67 mg. per cent, and the edema had diminished, possibly because 5 per cent glucose had been added to the fluid used to lavage the peritoneum (see Table I). However, he died, apparently from pulmonary edema, on June 9. The maximum urine output in any one twenty-four-hour period after operation never exceeded 825 c.c.

TABLE I. FLUIDS AND METABOLITES

| OPERATION | MAY | | | | | | | JUNE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Fluid intake (c.c.) | 2,000 | 2,000 | 2,250 | 3,545 | 2,220 | 1,010 | 2,550 | 2,150 | 1,550 | 1,500 | 0 | 85 | |
| Fluid output (c.c.) | 550 | 825 | 440 | 600 | 550 | 350 | 500 | 450 | 500 | 450 | 500 | 400 | |
| Blood urea $N_2$ | 21 | 49 | 79 | 66 | 74 | 62 | | 109 | | 92 | 87 | 77 | 67 |
| Peritoneal lavage | | | | | | | | | | | | | |
| Input (c.c.) | | | | | | | | | 8,250* | 22,700* | 23,800† | 23,200† | 14,100† |
| Output (c.c.) | | | | | | | | | 6,900 | 22,100 | 25,100 | 24,350 | 14,700 |
| Urea $N_2$ (grams) | | | | | | | | | 2.3 | | 10.89 | | |
| Total $N_2$ (grams) | | | | | | | | | | 24.3 | | 38.8 | |

*Hartmann's solution.
†Five per cent glucose added.

Autopsy was performed shortly after death by the pathologist at St. Barnabas Hospital. Nutrition was found to be good. The scrotum and ankles were edematous. There were surgical wounds 6 cm. long in each lower abdominal quadrant. The sclerae were icteric. There was a liter of cloudy fluid, containing flecks of fibrin, in the peritoneal cavity. The peritoneal surfaces were clean.

The left pleural cavity was obliterated by old adhesions, and the right contained 1,500 c.c. of clear, straw-colored fluid. There was mild coronary sclerosis, with cardiac hypertrophy and dilatation. The lungs exhibited basal atelectasis as well as moderate edema and emphysema.

The liver weighed 2,075 Gm. and the cut surface was a mottled reddish brown. The gall bladder was thin walled but contained many stones. The bile ducts were patent. The gastrointestinal tract, pancreas, and adrenals appeared normal.

The kidneys were enlarged (215 and 235 Gm.) but of normal consistency. Both cortex and medulla were thick, and the markings were distinct. The cut surfaces were dark red and homogeneous. The pelves and ureters were not dilated.

The bladder and prostatic cavity showed the effects of the recent operation. The prostatic capsule had been perforated on the right posterior wall, but there was no extravasation nor periprostatitis.

The central nervous system was not examined.

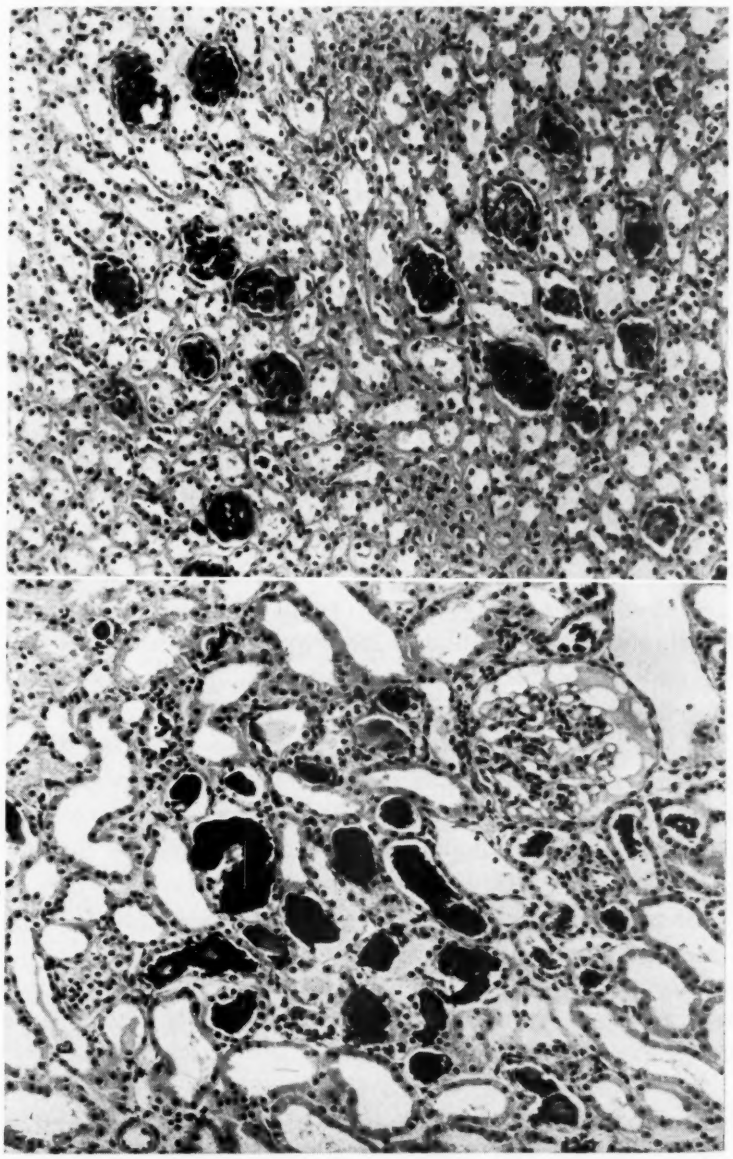

Fig. 1.—*A*, B. K., Section of kidney from autopsy (hemotoxylin and eosin, ×100). *B*, Renal biopsy seventy-two hours after transfusion with incompatible blood (benzidine stain, ×100).

*Microscopic Examination.*—In the lungs the alveoli were distended and contained a moderate number of red and mononuclear cells. The liver showed slight atrophy of central cord cells. In the prostate there was necrosis of cut surface with acute exudative inflammation. There were partially organized thrombi in larger veins. The myocardium had some fragmentation of muscle bundles and separation of fibers. In the kidneys (Fig. 1) pigmented casts filled the

collecting tubules. The epithelium of the convoluted tubules was flattened and their lumina were dilated. The interstitial tissues were infiltrated by lymphocytes and plasma cells. There was mild subintimal hyalinization of the arterioles, and the glomeruli were normal.

*Conclusions.*—Conclusions by the pathologist were recent transurethral prostatic resection, postoperative hemoglobinemia, obstruction of the renal tubules by hemoglobin casts, chronic pyelonephritis, uremia (clinical), hypertrophy and dilatation of the heart from hypertension, pulmonary edema, right hydrothorax, chronic passive congestion of the liver, cholelithiasis, and ascites (from peritoneal lavage).

## BRIEF REVIEW OF THE LITERATURE

It has been known for a long time that transfusions of incompatible blood may produce hemoglobinemia, hemoglobinuria, and renal insufficiency with oliguria or anuria. According to Flink, Denys in 1667 was the first to describe hemoglobinuria after the transfusion of incompatible (heterologous) blood in sheep. The renal changes which result from hemoglobinemia and hemoglobinuria are well known. They have been described in blackwater fever by Barratt and Yorke and by de Haan; after severe burns by Shen, Ham, and Fleming; after crush injuries (myoglobin rather than hemoglobin) by Bywaters and Beall; after obstetrical mishaps associated with infiltration of the uterine muscle with blood by Paxson, Golub, and Hunter; and after the transfusion of incompatible blood by many investigators.

The renal lesions in these conditions include vacuolation, necrosis, and desquamation of epithelium in Henle's loops and the distal convoluted tubules; pigmented casts are found in Henle's loops and in the convoluted and collecting tubules, and hemosiderin granules are seen in the convoluted tubules. There has been controversy over the nature of the pigmented casts, which have been called hemoglobin, methemoglobin, and acid hematin, but Flink stated that their composition is as yet unknown. They contain no iron, but give a positive benzidine reaction. There has also been disagreement over the exact cause of the renal insufficiency which accompanies the more severe lesions. Baker and Dodds and others have thought that the pigmented casts obstructed the nephron, a view which has been widely accepted and which is supported by the findings in our case; others, however, believe that the hemoglobin or some product thereof damages the renal tubules, and that the pigmented casts are shed by the tubular cells as the result of the action of a toxic agent, plugging being unimportant.

It has been shown experimentally that similar changes in the kidney follow the intravenous injection of solutions of hemoglobin (Levy), and laked red blood cells (Barratt and Yorke); the latter found that the renal lesions were less severe if the stroma of the red cells were filtered out first. The arrival of the hemoglobin in the kidney evidently produces a vasoconstriction since definite shrinkage of the organ has been detected immediately after intravenous injection of laked red cells in the dog by Levy, and of hemoglobin solutions in the frog by Mason and Mann, and in the dog by Hesse and Filatov. This may be of some importance in renal insufficiency after transurethral

prostatic resection, especially if the vasoconstriction is added to that already or concomitantly produced by hemorrhage, the presumption being that the resultant reduction in renal blood flow prolongs the contact between the hemoglobin and the kidney, thus enhancing both its toxic effects and the opportunity for mechanical plugging of the tubules. It seems possible that, in such circumstances, a relatively mild hemoglobinemia might be followed by damage to the kidneys, especially if they were previously abnormal (arteriosclerosis, pyelonephritis, hydronephrosis), as is so commonly the case in prostatism.

Flink has pointed out that hemoglobin is a threshold substance which is excreted by the glomeruli and reabsorbed by the tubules. Monke and Yuile found that the threshold in the dog varied from 80 to 150 mg. per cent; Gilligan, Altschule, and Katersky estimated it at 135, and Ottenberg and Fox at 288 mg. per cent or higher in man.

It is well established that a considerable quantity of hemoglobin must be present in the plasma before the kidneys are damaged. Sellards and Minot observed no untoward reaction after the intravenous injection into the human being of a solution made by hemolyzing 33 c.c. of packed red blood cells. O'Shaughnessy, Mansell, and Slome found no impairment of renal function after the injection of 50 Gm. of hemoglobin into a man, although it was followed by a hemoglobinuria lasting thirty hours. Altschule and Gilligan found the plasma hemoglobin to be 500 mg. per cent twenty-four hours after the onset of a severe hemoglobinuria in a patient whose nonprotein nitrogen subsequently rose to 90 mg. per cent, but who later recovered. Fairley and Bromfield observed three patients who died in anuria from blackwater fever; their plasma hemoglobins were 3.6, 4.6, and 5.1 per cent (3,600 to 5,100 mg. per cent). Flink found that all of his dogs which developed severe renal insufficiency after the intravenous injection of hemoglobin solutions or of laked blood had levels above 3,700 mg. per cent at the conclusion of the injection.

He has reported that about one-third of the hemoglobin injected intravenously into dogs could be recovered in the urine; it had ordinarily disappeared from the plasma in seventy-two hours, the remainder presumably having been taken up by the cells of the reticuloendothelial system.

The idea of Baker and Dodds that the harmful effects of hemoglobin upon the kidney can be averted by making the urine strongly alkaline beforehand, thus rendering the hemoglobin more soluble and preventing blockage of the renal tubules, has been widely accepted, and alkalinization before transfusion has been practiced extensively. However, others doubt the efficacy of alkalies. Thus, Foy and Kondi saw anuria in blackwater fever despite an alkaline urine. Walker found alkalinization of doubtful or no value even when given early for the hemoglobinuria of severe burns; Bywaters was skeptical of its merits in crush injuries; and Flink found that preliminary alkalinization of the urine of the dog did not influence the incidence nor the severity of the renal lesions which followed the injection of hemoglobin or of laked red blood cells.

It seems safe to assume that the deleterious effects of transfusions with incompatible blood are due to the transport to the kidneys of free hemoglobin which damages the renal tubules either by some direct toxic action, by the

production of vascular spasm, by plugging of the nephron, or more probably by all three. It seems equally evident that these same changes in the renal tubules can be produced by the intravenous injection of solutions of hemoglobin, and by laked blood, and that they also occur in other hemoglobinurias (blackwater fever, severe burns, and crush injuries), although in the last instance the toxic factor appears to be myoglobin. If hemoglobinemia alone is to damage the previously normal kidney, it must be very severe.

### CLINICAL APPLICATION TO TRANSURETHRAL PROSTATIC RESECTION

It is customary to use sterile tap or distilled water as the irrigating fluid in transurethral resection. During the course of the operation, especially if it is reasonably complete, many good-sized veins may be opened. The resulting hemorrhage necessitates running the water in at a rapid rate (hence under some pressure) in order to wash the blood away from the operative field sufficiently to permit the operator to see what he is doing. It is, therefore, easy to understand how the water, probably by now containing blood already hemolyzed in the bladder, may enter the venous system and there produce hemolysis. It seems possible that several effects may then be expected. First, some vasoconstriction in the kidney probably occurs. If bleeding has already produced, or subsequently produces spasm of the renal vessels, some damage to the kidney may be anticipated from a combination of these two factors. If the amount of free hemoglobin is small, it will be excreted in the urine where it escapes attention because of the usual postoperative bleeding. If the amount of free hemoglobin is considerable (it is too soon to speak in terms of actual concentration in the plasma in our clinical cases), plugging of the tubules and toxic changes in their epithelium will then occur.

On the basis of our experience so far, it seems unlikely that hemoglobinemia is often of sufficient severity in transurethral resection to damage the kidney irreparably, but rather that it is one important factor in producing such damage. Other factors which may combine with it include bacteremia, with resultant pyelonephritis, and renal vascular spasm from hemorrhage and from hypotension.

Flink and others have seen signs of regeneration in the tubular epithelium in from five to seven days after the onset of hemoglobinemia. If the patient can be kept alive sufficiently long, it is reasonable to assume that recovery may occur even in the presence of an initially severe renal lesion.

### TREATMENT

Keeping the patient alive with kidneys severely damaged as the result of hemoglobinuria taxes clinical judgment. One must strive to maintain fluid balance without overloading the circulation to the point of pulmonary edema. Oxygen therapy seems indicated in the initial stages, since vasospasm probably damages the tubules by reducing their supply of oxygen (Maegraith, Havard, and Parsons). Whether the use of the tent or mask can increase the oxygen saturation of the blood sufficiently to be of assistance is very doubtful,

but increasing the supply of oxygen available to the lungs can do no harm. It is possible that the intravenous administration of oxygen might be more helpful.

The intravenous administration of isotonic sodium sulfate has been advised by Necheles, Kroll, and Olson on the basis of their experience with dogs rendered anuric by experimental burns (shown by Shen, Ham, and Fleming and by others to be due to hemoglobinemia) where its use has been followed by diuresis in each case, but we have not tried it.

The acidosis which usually accompanies uremia must be controlled by the administration of alkalies without overloading the patient with sodium. The inevitable anorexia may require tube feeding and the administration of parenteral vitamins. In the early stages nasal suction may be needed for persistent nausea and vomiting. Proteins may require parenteral replacement, and the anemia resulting from blood loss and hemolysis may demand transfusion. Since a hemolytic reaction has already occurred, matching of the blood should be painstaking. Flink is of the opinion that measures to insure diuresis at the very beginning of the reaction, before oliguria has occurred, may help by diluting and promoting the excretion of the hemoglobin, but the forcing of fluids after oliguria has developed probably is responsible for many fatalities, as it apparently was in this case.

While waste products are piling up in the blood as a result of the oliguria or anuria, one may perhaps gain time for repair of the renal damage and may lessen the toxemia attendant upon the uremia by employing peritoneal lavage, a subject recently reviewed by Fine, Frank, and Seligman. We have had experience with this procedure in but two cases, the other a severe reaction from a transfusion of incompatible blood, and cannot yet evaluate it, but it reduced the urea nitrogen of the blood by 40 mg. per cent in four days in the case under discussion, and autopsy did not show evidence of any serious reaction in the peritoneum. In the second case, however, the lavage, after removing large quantities of nitrogenous substances from the blood, became ineffective after three days because of "walling off" around the inflow and outflow tubes, although it undoubtedly contributed greatly to the patient's recovery. Whether peritoneal reaction can be prevented by changes in the composition of the irrigating fluid (Hartmann's solution with 5 per cent glucose added), or whether it is due primarily to bacterial action, remains to be determined. It can be seen that, even with these limitations, peritoneal lavage may turn the tide in the patient's favor in some circumstances.

It is obvious, however, that the solution to the problem lies in the prevention of hemolysis during transurethral resection rather than in the treatment of the ensuing hemoglobinuria and its effects. One move in this direction consists in using the irrigating fluid at the lowest possible pressure, but the possibility of seeing clearly is unlikely with a pressure low enough to prevent the entrance of fluid into the circulation.

Another possibility is to employ an irrigating fluid which does not hemolyze blood. Saline solution cannot be used because, being a good conductor

of electricity, it diffuses the current from the electrode in the resectoscope enough to prevent satisfactory cutting and coagulating.

Five per cent glucose apparently does not cause hemolysis and so was tried, after this patient had died, at the instigation of Ebert, who had used it for some time for quite another reason. It has been used thus far in about twenty-five cases, and does not appear to interfere seriously with operation, although it does possess certain disadvantages. Postoperative determinations of free hemoglobin in the plasma have been made in every case and have shown measurable amounts in some instances (an effect of burning of tissue by surgical diathermy?), but no disturbingly high levels have yet been found.

Since blood is not hemolyzed, brisk bleeding interferes with vision more than it does when water is used because the medium is hazy, but this would be true of any nonhemolytic fluid, and so far has not been very troublesome.

Gloves become somewhat sticky as the glucose solution dries on them, but it is easily washed off.

Determination of the loss of blood by the method of Conger and Nesbit cannot be made without some modification of that method. Apparently if plain water is placed in the can in which the used irrigating fluid is collected, and if the sample is diluted with an equal volume of water before acid is added, the readings are satisfactory, but this needs further study.

It is theoretically possible, too, for a diabetic patient to suffer from the unwanted infusion of an unknown quantity of glucose during a transurethral resection with a glucose irrigating medium, but determinations of the blood sugar before and immediately after operation permits this situation to be dealt with.

Because of the possibility that the fluid used for continuous postoperative irrigation of the bladder may also get into the circulation, sterile half-normal saline solution is used for this purpose.

A search for a better fluid for use during operation is in order.

## SUMMARY AND CONCLUSIONS

1. The hemolysis of blood such as occurs during blackwater fever and after transfusions with incompatible blood or after severe burns leads to hemoglobinemia and hemoglobinuria.

2. If the hemoglobinemia is severe, it may damage the kidney by producing spasm of its vessels, by a direct toxic action, and by the production of pigmented casts which plug the nephron.

3. Intravesical and intravascular hemolysis may be produced during transurethral prostatic resection by the water used as an irrigating fluid. Burning by the current from the surgical diathermy machine may also cause some hemolysis, but this is probably of minor importance.

4. Hemoglobinemia probably does not harm the kidney unless the hemolysis is very severe, or unless the kidney is simultaneously damaged by vasospasm from excessive blood loss, by surgical shock, or by the transportation of virulent bacteria from the prostate to the kidney by the irrigating fluid.

5. A hemolytic reaction may be recognized in advance by measuring the free hemoglobin in the plasma at the end of the operation. This is recommended as a routine procedure with transurethral resection. The reaction itself is characterized by nausea, oliguria, a rising urea nitrogen, a mild jaundice, and an anemia out of proportion to the amount of blood actually lost during and after operation. The hemoglobinuria is masked by the usual postoperative hematuria.

6. The forcing of fluids during and immediately after operation may aid in excreting the hemoglobin with less damage to the kidneys, but after oliguria has appeared, one must be very cautious in administering fluids. Otherwise, treatment consists in trying to keep the patient alive until sufficient time has elapsed to permit recovery of the damaged renal epithelium. Peritoneal lavage may be of some value in achieving this end.

7. The hemolytic reaction can probably be prevented by using an isotonic solution, such as 5 per cent glucose, as an irrigating fluid during transurethral resection of the prostate.

8. A fatal reaction is reported in a case in which sterile water was the irrigating agent. Anorexia, hemoglobinemia, anemia, jaundice, and uremia occurred. Peritoneal lavage brought about a remarkable reduction in the urea nitrogen without a diuresis, but death occurred from pulmonary edema.

## REFERENCES


1. Altschule, M. D., and Gilligan, D. R.: Acute Massive Hemoglobinuria of Obscure Cause With Jaundice and Anemia, Arch. Int. Med. **68**: 957-978, 1941.
2. Baker, S. L., and Dodds, E. C.: Obstruction of the Renal Tubules During Excretion of Hemoglobin, Brit. J. Exper. Path. **6**: 247-260, 1925.
3. Barratt, J. O., and Yorke, W.: An Investigation Into the Method of Production of Blackwater, Ann. Trop. Med. **3**: 1-257, 1909.
4. Bingham, W. L.: Bilateral Cortical Necrosis of the Kidneys, J. Bowman Gray Med. School **3**: 256-260, 1945.
5. Bywaters, E. G. L.: Limb Compression in Tube Shelter Disaster, Lancet **2**: 373-379, 1943.
6. Bywaters, E. G. L., and Beall, D.: Crush Injuries With Impairment of Renal Function, Brit. M. J. **1**: 427-432, 1941.
7. Conger, K. B., and Nesbit, R. M.: Studies of Blood Loss During Transurethral Prostatic Resection, J. Urol. **46**: 713-717, 1941.
8. Denys: Cited by Flink.[14]
9. Duesberg, R.: Ueber die biologischen Beziehungen des Haemoglobins zu Bilirubin and Haematin bei normalen and pathologischen Zustaenden des Menschen, Arch. f. exper. Path. u. Pharmakol. **174**: 305-327, 1935.
10. Ebert, Carl: Personal communication.
11. Emmett, J. L.: Personal communication. Original idea from William McLaughlin, formerly a special Fellow in Urology.
12. Fairley, N. H., and Bromfield, R. J.: Laboratory Studies in Malaria and Blackwater Fever, Tr. Roy. Soc. Trop. Med. & Hyg. **28**: 141-156, 1934.
13. Fine, J., Frank, H. A., and Seligman, A. M.: Treatment of Uremia, J. A. M. A. **130**: 703-704, 1946.
14. Flink, E. B.: Certain Aspects of Hemoglobinemia, Thesis of the Graduate School of Medicine of the University of Minnesota, 1945.
15. Flink, E. B.: Transfusion Studies, Staff Meet. Bull., University of Minnesota Hospitals **15**: 368-378, 1944.
16. Foley, F. E. B.: Personal communication.
17. Fox, C. L., and Ottenberg, R.: Acute Hemolytic Anemia From Sulfonamides, Am. J. Physiol. **20**: 593-602, 1941.
18. Foy, H., and Kondi, A.: Blackwater Fever in Macedonia, Tr. Roy. Soc. Trop. Med. & Hyg. **31**: 123-138, 1937.

19. Gilligan, D. R., Altschule, M. D., and Katersky, E. M.: Studies of Hemoglobinemia and Hemoglobinuria Produced in Man by Intravenous Injection of Hemoglobin Solutions, J. Clin. Investigation **20**: 177-186, 1941.
20. Gilligan, D. R., and Blumgart, H. L.: March Hemoglobinuria, Medicine **20**: 341-395, 1941.
21. Goodpastor, W. E., Levenson, S. M., Tagnon, H. J., Lund, C. C., and Taylor, F. H. L.: A Clinical and Pathological Study of the Kidney in Patients With Burns, Surg., Gynec. & Obst. **82**: 652-670, 1946.
22. de Haan, J.: Die Nieren beim Schwarzwasserfieber, Arch. f. Schiffs-u, Tropen-Hyg. **9**: 22-32, 1905.
23. Ham, T. H.: Studies in the Destruction of Erythrocytes, Arch. Int. Med. **64**: 1271-1305, 1939.
24. Hesse, E., and Filatov, A.: Experimentelle Untersuchung ueber das Wesen des haemolytischen Schocks bei der Bluttransfusion, Ztschr. f. d. ges. exper. Med. **86**: 211-230, 1933.
25. Levy, L.: Untersuchungen ueber die Nierenveraenderung bei experimentelle Haemoglobinurie, Deutsches Arch. f. klin. Med. **81**: 359-382, 1904.
26. Maegraith, B. G., Havard, R. E., and Parsons, D. S.: Renal Syndrome of Wide Distribution Induced Possibly by Renal Anoxia, Lancet **2**: 293-296, 1945.
27. Mason, J. B., and Mann, F. C.: The Effect of Hemoglobin on the Volume of the Kidney, Am. J. Physiol. **98**: 181-185, 1931.
28. Monke, J. W., and Yuile, C. L.: The Renal Clearance of Hemoglobin in the Dog, J. Exper. Med. **72**: 149-165, 1940.
29. Necheles, H., Kroll, H., and Olson, W. H.: Effect of Infusion Fluids and Diuretics on the Anuria Resulting From Burns, Proc. Inst. Med. Chicago **15**: 393-394, 1945.
30. O'Shaughnessy, L., Mansell, H. E., and Slome, D.: Hemoglobin Solution as a Blood Substitute, Lancet **2**: 1068-1069, 1939.
31. Ottenberg, R., and Fox, C.: The Rate of Removal of Hemoglobin From the Circulation and Its Renal Threshold in Human Beings, Am. J. Physiol. **123**: 516-525, 1938.
32. Page, I. H., and Corcoran, A. C.: Post-traumatic Renal Injury: Summary of Experimental Observations, Arch. Surg. **51**: 93-101, 1945.
33. Paxson, N. F., Golub, L. J., and Hunter, R. M.: The Crush Syndrome in Obstetrics and Gynecology, J. A. M. A. **131**: 500-504, 1946.
34. Phillips, R. A., Dole, V. P., Hamilton, P. B., Emerson, K., Archibald, R. M., and Van Slyke, D. D.: Effects of Acute Haemorrhagic and Traumatic Shock on Renal Function of Dogs, Am. J. Physiol. **145**: 314-336, 1946.
35. Shen, S. C., Ham, T. H., and Fleming, E. A.: Studies on the Destruction of Red Blood Cells, New England J. Med. **229**: 701-713, 1943.
36. Sellards, A. W., and Minot, C. R.: Injection of Hemoglobin in Man and Its Relation to Blood Destruction With Especial Reference to the Anemias, J. Med. Research **34**: 469-494, 1916.
37. Van Slyke, D. D.: Quoted by Goodpastor et al.[21]
38. Walker, J., Jr.: Quoted by Goodpastor et al.[21]

# HYPERMOBILITY OF BONES DUE TO "OVERLENGTHENED" CAPSULAR AND LIGAMENTOUS TISSUES

## A Cause for Recurrent Intra-articular Effusions

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THIS paper is based on a study of recurrent effusions of the ankles or knees not associated with known external, local trauma. This was encountered in three white adults from 18 to 35 years old, who had experienced unilateral and occasional bilateral effusions of the knees, and in two others in the same age group, who had suffered from similar involvement of their ankles.* It was difficult, initially, to explain the basis for the habitual, widespread damage to the joint regions as evidenced by effusion and diffuse tenderness in the absence of any history of pronounced external, local trauma. On further examination of the articulations of these subjects, we observed an abnormal increase in the range of active and passive motion; there was primary hypermobility of the bones at many of the joints of the upper and lower extremities.† It seemed that an "overlength" of certain articular, capsular, and ligamentous tissues was probably the basis for the hypermobility. This laxity had permitted repeated damage to the capsular and ligamentous structures of the joints as a result of minor missteps or subclinical trauma probably suffered during routine physical activities.

With these points in mind, a summary of the clinical and radiographic findings of the five cases is presented. Emphasis is placed on the suggestion that, in the presence of such abnormal ligaments, especially about the knee, conservative therapy should be given an ample trial prior to any contemplated surgical procedure, even if the existence of a torn semilunar cartilage is suspected.

### CLINICAL FINDINGS

*History and Symptoms.*—In none of these five cases was there any known evidence of similar involvement of capsular or ligamentous structures of the joints of any member of the immediate family.[1] Three of the patients were not aware of any hypermobility in their articulations prior to entry into the armed forces, although they did suffer in civilian life from occasional enlargement of one or more of the joints of their lower extremities. The other two patients knew that their joints were lax but they had not sought medical aid

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*Besides these five patients with effusion of the knees or ankles not initiated by externally local trauma, we noted thirteen other white adults from 18 to 35 years old eleven male and two female, with generalized hypermobility of the bones, each with complaints of pain referable either to the back, neck, knees, legs, or feet, respectively. In each of these thirteen patients there was a definite external, local trauma to the affected part.

†Secondary hypermobility of the bones is usually compensatory to a contiguous ankylosed or rigid joint; for example, marked hypermobility of the bones at the knee is a frequent complication of a fused hip joint.

in civilian life. None of these five patients had suffered from multiple or recurrent fractures of the osseous system as is noted in osteogenesis imperfecta and which is occasionally complicated by hypermobility of the bones.[2] Two of the five patients complained of an increasing number of attacks or swelling, pain, limitation of motion, and weakness of their ankles during the course of military training. The other three experienced similar difficulties with their knees, with symptoms which suggested the possibility of the presence of a torn internal or external semilunar cartilage. In none of the five patients was there simultaneous involvement of the knees and ankles.

*Physical Signs.*—Two of the three patients presented unilateral, and one, bilateral, intra-articular effusions of the knees. During the acute, painful stage, the affected legs could not be fully extended or fully flexed because of the existent intra-articular effusion and the presence of spasm of the hamstring muscles. Tenderness was present over the course of the ligamentous structures and especially over the region of the internal or external semilunar cartilages. In the two cases of effusion of the ankles, local tenderness was present when pressure was applied over the region of the lateral and medial ligaments of the articulation. The normal depressions situated anterior to the outer and inner malleoli were partly obliterated. Active and passive plantar and dorsiflexion of the feet was restricted about 10 degrees in each direction, because of pain and effusion. Tenderness was also present in the subtalar and midtarsal regions.

Examination of the other (nonenlarged) articulations of the lower extremities of these patients revealed that a very unusual mobility of the bones existed in the hips, knees, toes, and subtalar regions, and, to a lesser extent, in the ankles. Such hypermobility was also present in the knee joints recently enlarged by an effusion, when re-examined two or three weeks after the onset of this swelling.

Specifically, the examination showed that in three of the five cases the range of total or combined passive abduction of the right and left thighs was from 85 to 105 degrees. These three patients also demonstrated an unusual range of passive extension of the thighs, the greatest angle of extension being from 195 to 210 degrees. Two of these five individuals were able to place their legs on the dorsal aspects of their cervical regions.

Each subject presented an abnormal arc of passive extension of the legs which measured from 190 to 210 degrees at the respective knee joints (Fig. 1). One patient could actively abduct and adduct his legs at the knee joints through a total arc of 15 degrees. This abnormal lateral mobility of the leg caused a temporary alteration in the configuration of the lower extremities from that of a mild knock-knee deformity to that of a bowleg. In four of these subjects there was marked laxity of the patellas to the extent that each could be passively displaced either laterally or medially for a distance measuring about one-half of its diameter. In the fifth, the patellas were so lax that they could be everted so that their articular surfaces were perpendicular to that of the femoral condyles. When the knees of these five patients were flexed at an

angle of 90 degrees, an increase of 5 degrees in the range of passive external rotation of the tibia was also observed. It is of further interest that abnormal, passive, anteroposterior movement of the tibia was found only in one patient, the one with the abnormal lateral mobility of the tibia. The feet of three of the five patients could be passively dorsal and plantar flexed to a total arc measuring at least from 10 to 20 degrees beyond the standard range. In two others, there was definite tautness of the Achilles tendon which restricted dorsiflexion of the feet to an angle of 90 degrees. The arc of inversion of the feet was almost 90 degrees* as evidenced by the ease with which three of the five patients could oppose the soles and toes of their feet while keeping their knees close together (Fig. 2). Furthermore, the foreportion of the feet was unusually lax

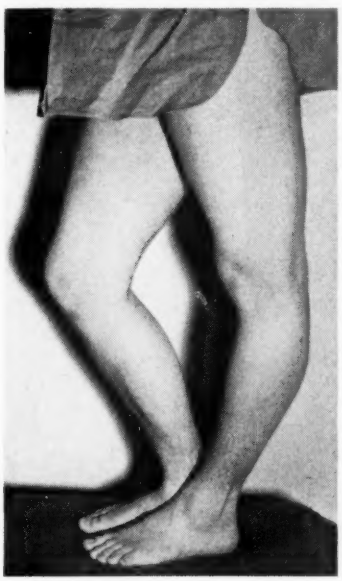

Fig. 1.

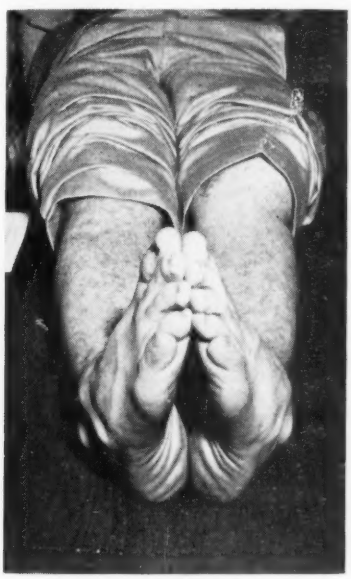

Fig. 2.

Fig. 1.—Note the abnormal increase in the range of extension of the left leg. This condition was also noted in the right leg.

Fig. 2.—Note the increase in the range of active inversion of the feet.

and could readily be compressed manually to increase the concavity of the metatarsal head region. Yet in spite of this unusual relaxation, not a single one of these five patients presented a marked depression of the inner longitudinal arches on weight-bearing. One patient had a unilateral relaxation of the deltoid ligament of the ankle which resulted in an eversion of the foot.

Examination also showed that three of the five could flex their trunks so that their chest walls were in close apposition to the anterior aspect of the thighs (Fig. 3). Likewise, these three patients could actively hyperextend their vertebral columns from 30 to 60 degrees dorsally beyond the vertical plane (Fig. 4).

*Effusion of the ankle may be noted in the presence of "overlengthened" midtarsal ligaments.

Examination of the upper extremities disclosed that in each of three subjects the arms could be hyperabducted to such an extent that the elbows approximated the opposite external ear. In one instance, mild downward traction to the arm caused a subluxation of the humeral head. Passive hyperextension at the elbow was also possible in these five cases and the greatest angle of extension at this articulation varied from 190 to 210 degrees. In addition, in one of these

Fig. 3.—Note the unusual range of flexion of the vertebral column.

Fig. 4.—Note the hyperextension of the vertebral column.

five patients a definite increase of 10 degrees in the total average range of passive radial and ulnar deviation of the forearm was present. The hands in these five instances could be translocated anteriorly without any difficulty. Passive palmar flexion of these hands was achieved to a point where the palmar aspect of the distal phalanges almost approximated the palmar aspect of the forearms and the tufts of the thumbs could be readily opposed onto the palmar surfaces of the forearms (Fig. 5). All fingers revealed an unusual range of hyperextension and abduction at the interphalangeal and metacarpophalangeal articulations, respectively. The fingers were also extremely hypermobile to such an extent that the metacarpal bone region of the thumb could be placed passively in close proximity to that of the little finger.

Fig. 5.—Note the increase in the arc of passive movement of the thumb.

One patient in this group of five had a mild laxity of the skin of the face but neither he nor the other four presented a generalized hyperelasticity or cutaneous nodules of the skin as is described in Danlos-Ehler's disease.[3] None of these patients with generalized hypermobility presented any weakness of the voluntary muscles, signs of postencephalitis,[4] "spider fingers,"[5] or any evidence of achondroplasia.*

*Radiographic Examination.*—In one of these five cases was there any evidence of fracture of the bones of the ankles or knees. Radiographic studies made of the upper and lower extremities in various attitudes confirmed the abnormal range of movement of the bones comprising the articulations as noted in the physical examinations. Radiographs of the knees showed that the range of hyperextension was limited by the apposition of the tibial plateau to the contiguous femoral condyles (Fig. 6). Active lateral adduction of the tibia as

*We observed hypermobility of the bones comprising the knees of a mother and her 5-year-old daughter, both of whom presented classical pictures of achondroplasia.

noted in one case caused a definite increase in the height of the lateral joint space of the knee joint (Fig. 7). In addition, examination demonstrated that in three instances there was an unusual mobility of the vertebral column in flexion and extension of the trunk.

As far as the upper extremities are concerned, radiographic examination of the shoulder joints disclosed that in the hyperabducted position of the arm, the greater tuberosity of the humerus was contiguous to the inferior lip of the

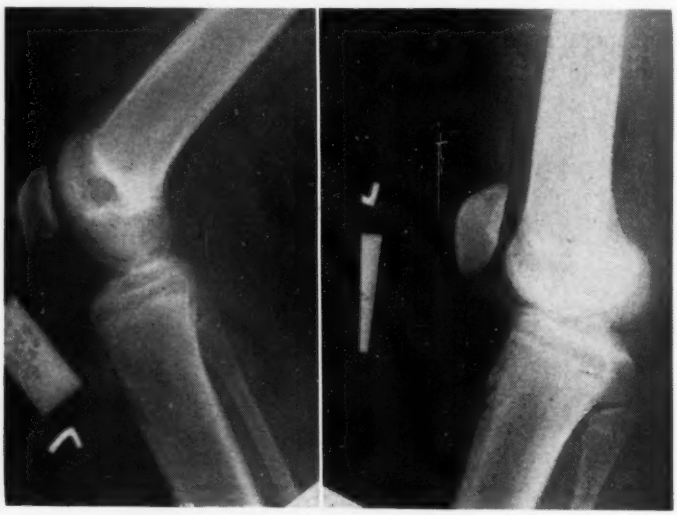

Fig. 6.—Radiographs showing the knee in flexion and in hyperextension. Note the apposition of the anterior portion of the tibial plateau to the femoral condyles.

Fig. 7.

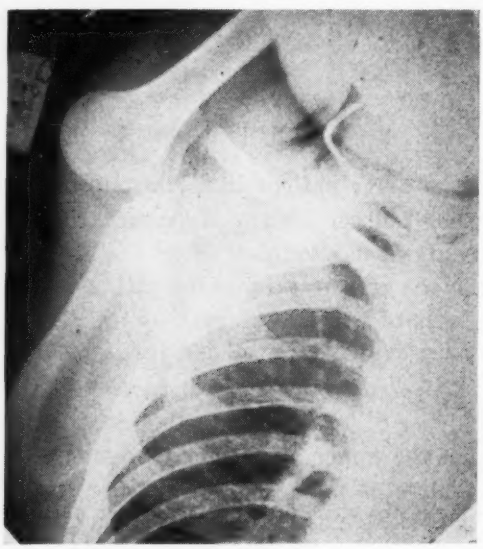

Fig. 8.

Fig. 7.—Radiographs demonstrating the relative increase in the joint space in the outer half of the right and left knees. This patient was able to abduct and adduct his legs actively.

Fig. 8.—Radiograph of shoulder region shows the extreme range of abduction of the humerus. The greater tuberosity of the humerus is at the level of the inferior rim of the glenoid.

glenoid of the scapula (Fig. 8). Subluxation of the humeral head was noted on mild downward traction of the arm.

Passive hyperextension at the elbow joint was also observed in these radiographic studies. The increase in the range of passive palmar and dorsiflexion

Fig. 9.

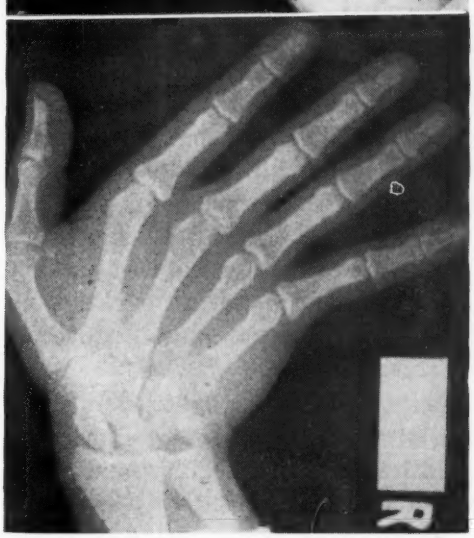

Fig. 10.

Fig. 9.—Radiograph of hand shows unusual range of active abduction and adduction of the fingers.

Fig. 10.—Radiograph of hand demonstrates a typical fixed "windmill sail" position of the fingers.

of the hand was reflected by an unusual range of mobility of the capitate bone. There was also an extreme range of active and passive abduction of the fingers and this occurred chiefly at the metacarpophalangeal articulation* (Fig. 9).

*Two additional cases not included in this series were studied which presented a fixed ulnar deviation of all the fingers, probably secondary to an anomaly of the metacarpal bones and of the ligamentous structures of the metacarpophalangeal articulations. The abnormal attitude of these fingers could not be fully corrected by either passive or active manipulations. Radiographic studies revealed that the proximal phalanges of these fingers articulated with only part of the metacarpal heads (Fig. 10). It is of interest that in one of the five cases of primary hypermobility in this series, we noted a mild degree of fixed ulnar deviation coexistent with a definite increase in the range of passive extension of the fingers. The abnormal, fixed, ulnar attitude of these digits has been designated as a "windmill sail deformity."[6] This must be sharply differentiated from acquired abnormal contractures caused by infectious processes of the joints of the hand.

## TREATMENT

The general course of treatment for effusions of the ankle or knee was bed rest and application of cold or warm compresses to the painful part. Traction was instituted to the leg in order to relieve the spasm of the hamstring muscles. Aspiration of the articular cavity was performed if the effusion obliterated all landmarks. When the pain subsided, nonweight-bearing resistance exercises were initiated to strengthen the quadriceps muscles. An elastic bandage was placed about the ankle or knee to permit weight-bearing as soon as the effusion had disappeared. Approximately seven to fourteen days of traction resulted in a complete relaxation of the spasm of the hamstring muscles. In order to prevent recurrence of the effusion and pain, the use of an elastic support with concomitant muscle training was stressed. Although it appeared logical that in certain instances treatment should have been directed toward shortening or imbrication of the abnormal ligamentous structures, such procedures were not pursued in this study. Some of the patients were reassigned to special duties which did not require excessive use of their lower extremities and others were separated from the armed forces when no adequate positions were available.

## DISCUSSION

There has been no available material for microscopic study to determine whether there is an actual increase in elastic tissue content of the ligaments or capsules in cases of hypermobility of bones. We suspect that the basic abnormality is an intrinsic "overlength" of the certain ligaments and capsules with a secondary disturbance of the normal check mechanism. While relaxation and secondary lengthening of the ligamentous structures as that covering the pubic symphysis can be experimentally induced in certain animals by subcutaneous injections of estrogenic hormones or be present during the latter period of pregnancy, we could find no clinical evidence of any hormonal disturbance in these five patients.[7]

It appears that a probable cause for hypermobility is a disproportion in the relative rate of growth of the bones and their attached ligaments.* Thus, an excess of ligament could lead to hypermobility, and an insufficiency to rigidity of the bones comprising the articulations.

Recognition of the status of the ligamentous and capsular tissue is of value especially in the plan of treatment of affections of the knee joint. In three

*As a correlative study, we examined the range of motion of the joints of 235 young male adults from 18 to 35 years who were patients in the orthopedic wards. We noted that ten patients or 4 per cent of the group presented evidence of hypermobility of three or more pairs of joints without any concomitant hyperelasticity of the skin. Two of these ten patients had unilateral, recurrent subluxation of the humeral head and a third had severe flat feet. The remaining seven patients showed orthopedic lesions, as fractures, etc., not specifically related to the hypermobility of the bones. In these 235 patients, six showed localized hypermobility of the knees; twenty-nine, of the thumbs; and eight, of the ankles. At this time, those with localized hypermobility of the knees, thumbs or ankles had no complaints referable to these parts.

A study was also made of the movements of the joints of twenty-five newborn infants. It was interesting to observe the universal wide range of passive dorsiflexion at the ankles, which permitted approximation of the tufts of the toes to the legs. Furthermore, in all of these infants, the tufts of the thumbs and of the fingers could be made to touch the palmar aspect of the forearms. No instances of hypermobility at the knees were encountered. Examination of twelve children aged from 3 to 8 years revealed that hypermobility of the thumb and fingers was noted in six instances and that hypermobility in the knee joints was present in three cases.[8] This limited study suggested that in certain stages of development of the skeleton the rate of bone growth may not be parallel to that of the ligamentous and capsular tissues. This may lead to a relative excess or insufficiency of ligaments with either laxity or rigidity of the bones comprising the joint.

cases of recurrent effusion of the knees not associated with trauma and in the other instances of hypermobile knees associated with trauma, the existent symptoms and signs simulated that caused by a torn internal or external semilunar cartilage. These are the patients in whom arthrotomy should be postponed until conservative therapy and a change in duty have been given a fair and reasonable trial. Where arthrotomy was done in two instances of recurrent effusion and hypermobility of the knee associated with external trauma, we noted the presence of fissures in the articular cartilage of the patella and no evidence of a torn or displaced semilunar cartilage. In considering the various causes for protracted effusion of the knee, as infectious arthritis, idiopathic, intermittent hydroarthrosis, or effusions associated with syphilis, one should not overlook hypermobility of the bones at the articulation.

Recurrent effusions of the ankle either with or without trauma in the presence of "overlengthed" ligaments of the ankle joint or of the midtarsal region should be treated by a trial of conservative methods as ankle supports, strapping, and muscle exercises. Change in duties which limits the use of the lower extremities is an essential part of the treatment in such cases.

It must be emphasized that hypermobility may be the cause for low back pain, cervical rib syndrome, flat feet, and the basis for recurrent subluxation of the intercarpal region, humeral head, or patella. In any event, surgical intervention is indicated for correction of the subluxation in instances of recurrent, protracted, disabling, frank subluxations of the astragalus, carpal bones, humeral head, or patella, when associated with or without hypermobility.

## CONCLUSION

In five patients with "overlengthened" capsular and ligamentous structures of the joints of the upper and lower extremities (primary hypermobility of the bones) we noted the presence of recurrent effusions of the ankles or knee joints in the absence of pronounced external, local trauma. The hypermobility of the bones at the joints permitted the occurrence of subclinical traumas to these parts, especially following prolonged periods of weight-bearing as pursued in military training. When the knees were involved, the symptoms and signs simulated that caused by a torn semilunar cartilage. In the presence of hypermobility of the bones, conservative therapy should be given a fair trial before contemplation of arthrotomy of the knee for removal of a semilunar cartilage. A change in duty restricting excessive use of the knees may prevent recurrent effusions.

The etiology of the "overlengthened" ligaments is unknown. No clinical evidence of any hormonal disturbance could be established. In these five instances no evidence of generalized hyperelasticity of the skin or anomaly of the skeleton was noted.

## REFERENCES

1. Key, J. A.: Hypermobility of Joints as Sex Linked Hereditary Character, J. A. M. A. 88: 1710-1712, 1927.
Sturkie, Paul D.: Hypermobile Joints in All Descendants for Two Generations, J. Hered. 32: 232-234, 1941.
Whitney, L. F.: Inheritence of Double Jointedness in Thumb, J. Hered. 23: 425-426, 1932.

2. Key, J. A.: Brittle Bones and Blue Sclera, Hereditary Hypoplasia of the Mesenchyma, Arch. Surg. **13**: 523-568, 1926.
3. Benjamin, Ben, and Weiner, Hyman: Syndrome of Cutaneous Fragility and Hyperelasticity and Articular Hyperlaxity, Am. J. Dis. Child. **65**: 247-257, 1943.
Coe, Meyeron, and Silvers, Seymour H.: Ehlers-Danlos Syndrome, Am. J. Dis. Child. **59**: 129-135, 1940.
Ronchese, F.: Dermatorrhexis, Am. J. Dis. Child. **51**: 1403-1414, 1936.
Tobias, Norman: Danlos Syndrome Associated With Congenital Lipomatosis, Arch. of Dermat. & Syph. **30**: 540-551, 1934.
4. Michaels, Joseph J., and Searle, Olive M.: A Case of Hypermobility of the Joints With Superimposed Postencephalitic Parkinsonism, J. of Nerv. and Ment. Dis. **77**: 246-255, 1933.
Rocher, H. L.: Dysplasies Musculaires atoniques avec laxité articulaires, Bull. Soc. pediat. de Paris **33**: 287-292, 1935.
5. Parker, Seymour A., and Hare, Hugh F.: Arachnodactyly, Radiology **45**: 220-226, 1945.
6. Boppe, M., and Faugeron, P.: La Deviation Congenitale des Doigts "En Coup de Vent," Revue d'Orthopedie **26**: 547-557, 1939.
Dreyfuss, Max: Beitrag zum der Angeborenen "Windmühl enflugelstellung" der Finger (Deviation des doigts en coup de vent), Ztschr. f. orthop. **65**: 205-225, 1936.
7. Sinelnikoff, E., and Grigorowitsch, M.: Die Beweglichkeit der Gelenke als sekundares geschlechtliches und Konstitutionelles Merkmal, Ztsch. f. d. ges. anat. **15**: 679-693, 1931.
Sutro, C. J., and Pomerantz, L.: Effects of Estrogen on Bones, Joints and Ligaments of Castrated Guinea Pigs, Arch. Surg. **39**: 992-1000, 1939.
8. Finkelstein, Harry: Joint Hypotonia With Congenital and Familiar Manifestations, New York State M. J. **104**: 942-944, 1916.
Jahss, S. A.: Hypotonia, New York State M. J. **109**: 638-639, 1919.
Sobel, J.: Essential or Primary Hypotonia in Young Children, M. J. & Record. **124**: 225-230, 1926.

# VASCULAR WOUNDS

## Report of a Series of 108 Cases Encountered in a Forward Evacuation Hospital

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THE experiences and impressions herein related are derived from observance of approximately 25,000 wounded treated by the evacuation hospital in which the author was fortunate enough to serve as chief of the Surgical Service.

When the unit landed with the invasion forces in North Africa, the literature on management of vascular injuries was not profuse. A number of axioms had been handed down from World War I, and the Spanish Civil War had furnished some further experience. The Manual of Therapy as compiled by the Surgeon General's Office and The National Research Council resolved the previous experience into axiomatic summary as follows: (1) Companion vein ligation; (2) ligation, if possible, immediately caudad to the last large branching vessel above the injury.

Although the field of vascular surgery may seem at times to be too specialized to be of general interest, when vascular complications of injured extremities do suddenly confront the surgeon, a ready appreciation of the sequelae of injury at various levels may well aid in deciding between a conservative or more radical type of management. Since the preservation of life in a limb is probably determined within a very few hours after injury, it is well to try to examine and evaluate the experience of war where injuries of the extremities form such a large proportion of those wounded, so that this may be recorded for future reference, as well as for its possible pertinence to civilian practice in effecting, if possible, a higher salvage of the badly injured extremities so often encountered in industrial as well as highway and other transportation accidents.

In the North African invasion, the majority of wounded suffered from injury by small arms fire, and vascular complications requiring amputation for decreased blood supply were relatively few. In the subsequent Tunisian campaign, land mine injuries often resulted in traumatic amputations at levels below the knee, but again vascular injuries were not too numerous. During this campaign sixteen patients were treated for gas gangrene. In twelve of these, the infection developed in limbs where injury rendered the distal limb avascular, or relatively so, and while attempting to save it by sympathetic blocks and vasodilatory drugs the anaerobic infection supervened. This, then, became one of the major complications of vascular injury, but since its incidence was relatively small and war surgery so completely new to those of my unit, the seemingly more dramatic abdominal[1] and chest wounds[2] were more thoroughly scrutinized and reported. However, in approximately 4,000 wounded

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treated by us in the North African, Tunisian, and Sicilian campaigns, roughly 81 per cent had extremity wounds and about one per cent had amputations. DeBakey[3] has recently summarized the Army experience for the war. In 163,980 battle casualties, arterial wounds occurred with an incidence of 1.4 per cent, and were the cause for amputation in 19.4 per cent of those amputations performed. Inversely, of 2,300 arterial wounds, 40 per cent required amputations.

Upon arrival in Normandy, D Day plus 4, the unit was flooded with casualties, handling over 6,000 in the first thirty-one days and operating upon 4,000 of these. Wounds of the extremities occurred in 74.4 per cent of the wounded, and amputations were required in 1.1 per cent of the extremity wounds, usually because of avascularity. Observation and review of these injuries soon revealed a rather constant series of conclusions, of which the most obvious and constant was gangrene involving the lower three-fourths of the leg (below the knee) in popliteal injuries. In three patients with severe posterior dislocation of the knee joint, encountered early in the African campaign, popliteal injury had occurred in two, with loss of the distal limb from gangrene.

With the increasing frequency or incidence of vascular wounds, and the too constant, distressing results of passive therapy, a more energetic regime was instituted, with careful records of the results. The greatest incidence of major vascular injuries thus handled occurred during the battle of the Ardennes. Thereafter, the relative incidence seemed to decrease. Monthly records were kept, and bore out this observation.

For the sake of easier discussion, the injuries will be discussed in sequence of their anatomic location cephalad to caudad. The management will be discussed following the record of the cases. The series includes 108 patients on whom records were kept, 106 of whom were operated upon, the other two being conservatively treated for arteriovenous fistulae.

The most interesting of these vascular wounds were those involving major arteries. Ninety of the series were treated during the battle of the Ardennes, which was actually between Dec. 10, 1944, and Jan. 22, 1945. Conservation was the keynote of the management, although individual variations in technique did occur as the result of the relatively large number of surgeons operating in the unit (twenty-two). In the great majority of patients, loss of vessel substance was too great to allow anastomosis, with Blakemore tubes not being available for vein transplants, nor anticoagulants for preventing thrombosis subsequently. Many times, anastomosis seemed at first feasible until closer examination revealed the intima to be destroyed a considerable distance beyond the apparent loss of media and adventitia.

The principles of management striven for were maximum preservation of circulation by vascular reconstruction if possible, by routine sympathetic block every twelve hours, by reduction of the metabolism of the extremity to a minimum by cooling. In the case of cervical sympathetic blocks, the anterior approach seemed more satisfactory, with a positive Horner's response produced much more frequently.

The following observations cover 108 cases. The most cephalad injury involved an external carotid which required ligation, without sequelae. Exclusive of a patient with arteriovenous fistula treated conservatively, there were, in addition, forty-six cases involving major vessels of the upper extremity. The most major injury of these involved both subclavian artery and vein. A soldier's tommy-gun accidentally discharged twice in rapid succession, both bullets entering the left chest at the same level just above the nipple, approximately one-half inch apart, and leaving posteriorly above the scapular ridge about one inch apart, again at the same level. Compression and transfusion controlled the patient's condition during preparation for operation. Under general anesthesia, the subclavian was controlled after being exposed by subperiosteal resection of the proximal third of the clavicle. Almost immediately following placing of the control tape about the vessel proximal to the wound, the thrombus which had formed in the vessel's end let go, but the bleeding was under satisfactory control. About an inch of artery had been shot away, as well as all of the subclavian vein from its junction with the internal jugular to its axillary portion. The artery was tied proximally and distally. Immediately thereafter the distal portion was seen to fill with blood, indicating adequate circulation. The vein was ligated at the jugular and distally. The extremity remained warm. Motor and sensory loss were present from the time of injury, although the brachial plexus grossly appeared uninjured at surgery, and paresthesias developed after several days.

There were also three cases of injury to the axillary artery at a high level, one being encountered in the European campaign, in which both artery and vein were ligated and divided and circulation remained adequate. A second but earlier case of high axillary artery loss was encountered during the Sicilian campaign. About an inch of the vessel had been shot away. The artery was ligated proximally and distally. The companion vein was ligated and divided. The patient developed considerable edema and, eventually, slight gangrene of the finger tips. This earlier case had not had as many or as energetic cervical sympathetic blocks, and these had been done by the posterior instead of the anterior approach.

The third axillary artery injury required ligation in the distal third. The companion vein was not ligated, and the patient developed slight dry gangrene of the tip of the thumb and middle finger.

There were twenty-seven patients with injuries to the brachial artery. Seven had injuries above the level of the origin of the profunda. An eighth, similarly injured, will be discussed separately. Five of these injuries were ligated and two were repaired. In two of those ligated, with an associated humeral fracture, gangrene developed in the forearm complicated by rapidly advancing gas bacillus infection, and emergency high amputation was necessary. One of these patients died of pulmonary embolus later. The eighth patient, thought to have been injured at approximately this level with an associated compound fracture, was débrided in a field hospital, given two stellate ganglion blocks for a cold extremity, and brought to the evacuation hospital four days later. Gas gangrene developed shortly, despite further cervical

sympathetic blocks, and required high amputation. Two days later the patient died an embolic death. In the three remaining patients, ligated under the regime of cooling and cervical sympathetic blocks at twelve-hour intervals, all demarcated and went on to dry gangrene, one at the metacarpophalangeal level, another just above the wrist, and the third just below the elbow. The two patients whose vessels were repaired had lacerations involving three-fourths of the circumference. Following repair, both of these patients regained radial pulses and maintained adequate circulation to the extremity, later being evacuated in good condition.

Of the nineteen brachial artery injuries below the profunda, three had vascular repairs: one of these latter had thrombosis in an intact vessel, secondary to a missile passing close by. After removal of the thrombus and vessel repair there was a brief, questionable pulse but circulation remained adequate. A complete brachial artery severance was repaired by anastomosis. Although no radial pulse returned, circulation remained adequate. The third repair, of a laceration involving only one quarter of the vessel circumference, likewise failed to effect a return of the radial pulse. The hand remained cool, and there seemed a possibility that some fingers would need later amputation, though after ten days this was still uncertain. The results in the remaining sixteen cases of ligation cast doubt that survival in the above can be in any way ascribed to the repair. One patient with the brachial tied just below the profunda retained uncompromised circulation. In eleven patients with severance and ligation of the vessel in the middle third of the arm, there were only two with insufficient collateral blood supply to the distant extremity, both proceeding to dry gangrene. One subsequently must have lost much of his hand and the other probably required amputation later, in the lower third of the forearm about the wrist. The remaining four patients had interruption of the blood supply in the distal third of the arm. One patient with level of injury two inches about the elbow developed a dry gangrene and probably required later amputation in the upper third of the forearm. The other three fared much better. One patient with the artery divided just above the bifurcation into the radial and ulnar arteries developed a dry gangrene of the finger tips. A second with a thrombus at the same level had a cool hand but seemed well on the way to saving all of it. The last of the three, with level of injury at the elbow joint, had no circulatory inadequacy.

There were fifteen patients with ligation of the radial, ulnar, or both arteries: seven radial, five ulnar, and three combined, one of the latter being at the wrist level. Circulation was adequate in all patients.

There were fifty-nine patients with injury to major vessels of the lower extremities treated operatively, including one fatal injury involving the right common iliac at the aortic bifurcation. Attempted repair failed, and the surgeon was forced to ligate above the site of injury. The patient died of shock twelve hours after surgery, with limbs avascular.

Injuries of the external iliac artery occurred twice. In one, the vein had been shot away and the artery thrombosed for a distance of 6 or 7 cm., with vessel wall black from extravasated blood. The thrombus was twenty-four

hours old at time of operation, and firmly adherent; the vessel was nonviable, so it was ligated and divided. Amputation was later performed at the lower third of the thigh. The other patient was brought to the hospital four days after wounding and three days postoperative (Field Hospital) of a cystostomy following a fractured pelvis with early gangrene of right thigh and leg below the inguinal ligament. At amputation five days later the vessel injury was found to be at the level of the external iliac, the hypogastric being apparently intact. Circulatory interference was so extensive that disarticulation of the hip was finally necessary.

One patient had a severe wound of the external iliac vein immediately distal to the junction with the hypogastric, but no arterial injury. Exact location of the injury was determined during an intra-abdominal operation for associated intestinal wounds, and it was readily controlled by an extraperitoneal ligation distal to the injury. This was accomplished quite simply and rapidly by exposure of the iliac vessels above the inguinal ligament though a separate incision. This method of approach is advocated for control of high femoral artery injuries, in order to place a preliminary prophylactic control tape before exposure of the actual arterial injury.

In the series there were three patients with femoral artery injury above the profunda femoris. One had thrombosis of the femoral artery at this level. The vessel was opened, thrombectomy performed, and the vessel repaired. The foot, which was cold before operation, was now warm, although no pulse could be detected. Circulation remained adequate. My only explanation is that removal of the thrombus allowed the vasospastic reflex to be ameliorated and responsive to lumbar sympathetic blocks, and mural thrombosis about the injured intima did not completely occlude the vessel, or, by the time it did, collateral circulation became adequate. Pathogenesis of the original thrombus will be discussed later. The second femoral injury was in a patient with extensive loss of both artery and vein, extending at least 1.5 cm. above and below the origin of the profunda. Ligation was the only procedure which could be carried out quickly in a gravely injured patient. A high thigh amputation would have been necessary had he not succumbed the second postoperative day to a cerebral blast effect. The third of these high femoral injuries occurred in a prisoner of war, with loss of 1½ inches of femoral artery proximal to the profunda femoris. About 1½ inches of femoral vein was transplanted and anastomosed to fill the defect. Posterior tibial pulsations were present at the ankle for a little over twelve hours after surgery. As there was no anticoagulant available, secondary thrombosis supervened, and arterial emboli broke off, one lodging further distally in the posterior tibial artery, producing severe pain in the calf of the leg. A line of demarcation at the ankle eventually developed. In view of the results of ligation in patients with external iliac and other femoral injuries at this level, this is a very illustrative case. Patients with interruption of the arterial supply proximal to the origin of the profunda femoris usually have demarcation above the knee, despite all sympathetic blocks and other supportive measures. It would thus seem that in wounds proximal to the profunda, all possible reconstructive measures pos-

sible are imperative, and that even if secondary thrombosis of varying degree seems likely, a temporary reprieve from avascularity may give enough time for increased collateral circulation to develop, perhaps enough to save an additional joint, if not the limb. This may possibly follow a secondary decrease in the edema originally resulting from injury, or relaxation of vasospasm after a number of hours, either or both allowing increased vascular flow to the extremity.

In marked contrast to the series of wounds above the level of the origin of the profunda femoris, wounds of the femoral artery immediately below the profunda, the latter being intact, have a much better prognosis. There were fifteen patients in this category. One patient had two inches of femoral artery shot away shortly distal to the profunda. At the time of surgery his distal extremity was warm and remained so after ligation. Circulation remained adequate. It has been our experience that if the limb is immediately warm though pulseless after ligation, by rest, cooling, and sympathetic blocks it can be saved despite ligation. There were three patients with lacerations of the femoral artery, two of which lacerations involved three-quarters of the circumference. A dorsalis pedis pulsation was palpable after repair in two of the three patients, but circulation remained adequate in all. A fifth patient presented a warm foot but no demonstrable peripheral pulsations after removal of a thrombus of the artery at this level (distal to the profunda), the foot having been cold before surgery. The extremity remained viable. One other patient with a thrombus presented a warm foot initially, so the thrombus was not removed. The companion vein, having been lacerated, was ligated. The circulation remained adequate. The remaining nine femoral artery injuries in this group required ligations of the artery and vein. Three were upper third injuries (just below the profunda) without a sequelae. A fourth injury at almost the same height, however, resulted in eventual gangrene of several toes, though there seemed no doubt about being able to save the foot. Two cases of injury to the middle third resulted in gangrene; one limb demarcated at the ankle level and one at mid-calf level. Three patients with injury in the lower third presented widely different sequelae, however. One of these, with level of injury in Hunter's canal, had inadequate circulation for the toes and forefoot. The second, with the vessel ligated at the lower end of the adductor canal as it emerged lateral to the adductor muscle, had no circulatory inadequacy, and the foot remained pulseless but warm. The last of the three, with both artery and vein lacerated at this same level, developed a cold limb to the level of injury and will eventually need a mid-thigh amputation (the sequelae commonly following popliteal injury).

There were four cases where the profunda femoris was ligated, all without sequelae.

Eight popliteal artery injuries occurred. Thrombosis followed anastomosis in one patient, and amputation was carried out at the fracture site level, the knee. Another patient with compound fracture of both bones and popliteal injury at the level of the fibular head required later amputation at that

level. One patient, with the vessel tied two inches above the knee, demarcated in the middle third of the tibia, while four other patients, with the vessel ligated at the lower end of the femur, demarcated at the lower third of the tibia. All five of these patients on the cooling, bidaily-sympathetic-block routine presented a gangrene that was still dry at the end of ten days to two weeks. There has been only one popliteal injury in which the distal extremity was saved. This was in a prisoner of war. The artery was tied, and the vein stripped for a distance of two inches but not ligated. The patient's foot was warm before and after surgery, pulseless, but viable. There was a considerable number of other popliteal injuries associated with some compound fractures where, from previous experience, the obviously avascular limb required amputation. This was completed at the time of the original surgical treatment of the wound and extremity.

The remaining cases in the series were injuries of the anterior or posterior tibial vessels or both. They totaled twenty-five, eighteen of these involving the posterior tibial artery, one the anterior tibial artery, and six including both vessels. Thirteen of the eighteen posterior tibial ligations showed no inadequacy of circulation while four showed definite inadequacy, the severest ending in gangrene of the forefoot, the other three involving only the toes; the remaining eighteenth patient had a cool foot but did not go on to gangrene. There were no sequelae to the anterior tibial injury or to three of the six combined injuries. Of the remaining three, one, in which both vessels were injured just below the popliteal bifurcation associated with compound fractures of both bones at the same level, went on to gangrene and required amputation at ankle level, while the last developed some gangrene of the toes and superficial blebs over the dorsum of the foot, but the main portion of the foot continued to remain viable at time of evacuation several weeks after injury.

Arteriovenous fistulae were encountered several times in the femoral region, the result of tiny shell fragments traversing both artery and vein. Invariably the extremity was warm and they were left scrupuously alone. Complete records were kept in only two of the cases, however. In one case (included in series of high femoral ligations), energetic wound débridement just below the profunda resulted in severe hemorrhage necessitating ligation. There was an immediate cooling of the extremity. Although this limb was eventually saved, this fortunate result might well have not occurred had the injury been elsewhere. There can be no doubt that conservatism should emphatically be enforced in the early management of these wounds. In another similar case, the patient was left scrupuously alone. X-ray showed a very small missile responsible. There was no evident extravascular hemorrhage, and the circulation was adequate. Another patient seen early in the African campaign had an arteriovenous fistula in the subclavian in its outer portion, with apparently a false aneurysm under the pectoralis major. This patient was watched carefully for about ten days; as he seemed temporarily stabilized, and circulation was adequate to the extremity, he was evacuated. Unfortunately, follow-up could not be obtained.

## CONCLUSIONS

From the foregoing series of cases, a number of observations seem pertinent:

1. The critical sites of injury are mainly the brachial artery and femoral arteries above their respective profunda branches, and also the external iliac and popliteal arteries. Kirtley,[4] reporting vascular injuries seen in a general hospital in a theater of observations, noted that 20 per cent of the amputations were for circulatory causes, with about one-half following popliteal injury and approximately one-third following femoral artery injury.

2. Ligation below the critical sites here mentioned, in the absence of extensive wounds and tissue damage interfering with collateral circulation, will generally *not* result in loss of the extremity.

3. At the critical sites, every effort should be made at repair by silk and/or by vein transplant, including thrombectomy even in the absence of anticoagulants, vitallium, or plastic tubes (Blakemore), as the temporary partial sustenance of circulation to an extremity after anastomosis may be adequate for maintenance of a viable extremity, or, if secondary thrombosis does occur, it may allow sufficient time for the collateral circulation to develop enough to allow final gangrene demarcation level to be at least distal to a joint which might otherwise have had to be sacrificed. Kirtley[4] reported three popliteal injuries with Blakemore tube repairs with a viable foot, if not in toto, in part, although the anastomosis had thrombosed. Of twenty-nine patients with popliteal injuries, three of the four maintaining viable extremities had had lumbar ganglionectomies, the fourth, lumbar sympathetic blocks. Statistically, DeBakey[3] reports that various methods of repair, including the use of the vitalliun tube, gave no reduction in percentage of amputations required.

4. In our experience, sympathetic blocks and lowering of the metabolism of the extremities by cooling during the postoperative salvage period increase the amount of limb saved and favor the development of a dry rather than a wet gangrene. Slight elevation, enough to favor gravity drainage, also favors the development of a dry gangrene, and has, at times, seemed to be quite helpful in converting a moist to a dry gangrene.

5. The incidence of pulmonary embolism is appreciable in extensive injuries to the extremities involving the major vessels. The incidence of embolism seems particularly unfortunate after secondary amputation for gangrene. The need for all possible prophylactic measures is obvious.

6. In the presence of associated major fractures, collateral circulation is likely to be less able to furnish adequate sustenance for the injured limb, and the prognosis is influenced accordingly.

7. In injuries to major vessels, and frequently in cases of explosive missiles passing close by, thrombosis of major arteries is very common. In severed vessels this may be temporarily lifesaving and allow sufficient time for a temporary proximal control tape or ligature to be placed. This latter preliminary procedure is mandatory in the management of major vessel injuries where repair is contemplated, at the same time saving the patient from unnecessary loss of blood during débridement.

8. In all major extremity wounds, the status of the circulation should be immediately recorded and carefully watched throughout the operative and postoperative period. A warm extremity is always a good prognostic sign, even though pulsations are absent.

9. When major vessels must be ligated, as suggested by Holman,[5] if ligation is performed as close distally to the last proximal major branching vessel as possible, the chance of maximum collateral response seems greatest.

## SUMMARY

In conclusion, the experiences with wounds of the major vessels of the extremities as encountered in a war-combat zone have been detailed. It is felt that with all the industrial and highway accidents which occur in this country, the experiences being related may be translated with profit to the field of traumatic civilian surgery.

A series of conclusions or pertinent observations have been listed.

## REFERENCES

1. Rohlf, Edward, L., and Snyder, John M.: Surgical Experience With Abdominal Wounds in the North African Campaign, Surg., Gynec. & Obst. **79**: 286-296, 1944.
2. Snyder, John M., and Tropea, Frank, Jr.: War Injuries of the Chest, Report of 678 Cases. In Press.
3. DeBakey, Michael E.: In Press.
4. Kirtley, James A.: Arterial Injuries in a Theater of Operations, Ann. Surg. **122**: 223-234, 1945.
5. Holman, E.: Further Observations on Surgery of Large Arteries, Surg., Gynec. & Obst. **28**: 275-287, 1944.

# PRACTICAL POINTS IN WOLFE GRAFT TECHNIQUE

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GROSS principles in technique of application and postoperative care of Wolfe grafts are, of course, recorded in the literature. Many small points, however, seem to determine the success or failure of this valuable graft. It is these we wish to discuss in the light of an exceptionally large series in one of the Army's plastic surgery centers. Free skin grafting must be carried out with the most meticulous care, especially when the graft is thick, for then it is more easily the victim of complications which may cause its partial or total failure. Incidental to the handling of over 100 grafts of this type during the past year, a survey of factors determining their success seems pertinent at this time, for they have not all been, to our knowledge, conspicuously emphasized heretofore in the literature.

Because this graft is more durable, shrinks less, and provides a better color match—and is, therefore, superior functionally and cosmetically—we have elected the Wolfe graft whenever the defect has not been too extensive, the recipient area is favorable enough, and the best appearance and greatest durability are desirable. This is particularly true of exposed portions of the body and upon areas subjected to trauma. The operative procedure in application of full-thickness free grafts is merely the beginning of a series of equally important technical steps, and the optimum end result is obtained by meticulous aftercare and cautious attention to principles of plastic surgery which are demonstrated more clearly in this type of graft than in any other. A full take, most favorable appearance, and substantial quality are found to justify every extra precaution which determines or enhances its success.

## CHOICE OF DONOR SITE

Choice of donor area is of foremost importance, particularly when the defect is upon the face. It is generally conceded that upper eyelid and postauricular tissues provide the most perfect quality and color matching for small facial defects. For larger areas, we believe with other workers in this field that the lower neck or clavicular region is superior to any other. It is remarkable what large donor areas can be directly closed after local undermining. It is a simple matter to apply an ordinary split-skin graft to areas too large for direct closure. Inside surface of the upper arm or lateral thoracic wall provides good quality skin, but the color is less favorable. Skin of the back or abdominal wall is objectionably thick. Thigh skin provides a good utilitarian Wolfe graft, as for

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the hand or foot. Some hairs may survive in a thick free graft (and sometimes even in a thick split graft). Thus, a hairy chest is worth considering for the beard area of a man.

It might be noted that donor skin for a defect upon the dorsum of the nose may match much more accurately if a split graft is removed from the donor site and allowed to heal prior to the main operation. This gives the area an "orange peel" appearance, particularly desirable if the individual has enlarged pores so commonly noted upon the nose. The lateral chest wall is a good site for this type of procedure. Usually three weeks or more following the removal of the thin graft the full-thickness graft can be cut to pattern from this natural appearing donor site.

## THE RECIPIENT SITE

Let us review the basic requirements of the recipient site. Since the graft is nourished from the base rather than edges, its recipient bed must be clean and vascular. Mobile and avascular structures cannot be successfully covered unless they comprise an area so minute that the timely lateral progress of capillaries permits the graft's survival thereupon. It is occasionally noted that a Wolfe graft will bleed when trimmed 1 or 2 mm. from the vascular recipient bed; it is this fact which enables it to survive over very limited exposure of avascular structures. Perfect gentle, firm, and constant pressure should be maintained following removal of stitches and the early dressings, a total of three weeks or more. Believing that meticulous care of the recipient site throughout this entire period is fully as important as the initial surgical technique, our purpose is to describe several observations which have improved our results and which seem to determine the success or failure and degree of satisfaction to patient and surgeon.

## TECHNIQUE

Most, if not all, technical descriptions of the procedure state that such grafts should be cut the same size, to an exact pattern, as the recipient area. We are, however, convinced that the Wolfe graft should be cut approximately 20 per cent larger, to allow for inevitable and relentless shrinking and to avoid any tension at its periphery during or following the operation. Since doing this routinely, we note an improved ultimate quality of the graft, and the scar line about its periphery shows less tendency to widen, hypertrophy, and require secondary revision.

Various means of making a pattern are available. Among them are the use of tin foil, oiled silk, thin sheet rubber, one of the transparent substances used for dressing denuded surfaces, nylon fabric, and so on. We are saving the time usually required in cutting out such patterns by placing a single layer of dry fine mesh gauze over the defect, pressing it in lightly to identify the edges, and then delineating an outline of the defect upon the gauze with dye. The gauze is then laid upon the donor area and the shape of the defect transferred to it by touching the line about every ¼ inch with a pen or sharpened applicator dipped in the dye. Upon discarding the gauze, the dots show plainly

upon the skin; they are connected with a line of the dye. Thus, a replica of the defect has been traced upon the donor area within a period of about three minutes. The incision may then be made outside the line according to how much larger it is desired to cut the graft—usually 1/16 to 3/16 inch—to make the graft somewhat larger than the pattern.

When the graft is dissected from its donor site, every morsel of subcutaneous fat is removed from its undersurface; in fact, a bit of the corium is commonly removed in order to be certain. After dissecting it up with rather bold strokes of a sharp scalpel, we find that sharp straight scissors provide the most efficient means of removing the remaining bits of fat. Complete hemostasis is, of course, a necessity. This can be facilitated in both donor and recipient areas if incision and dissection are preceded by injection with normal saline solution or 1 per cent novocain solution containing a few (usually 3 to 8) drops of adrenalin per ounce. When a vessel must be tied, we prefer very fine silk or cotton to catgut; it has been amply demonstrated that the latter is the most irritating of these materials. The graft should be secured in its recipient site by placing sutures at salient points so that tension will be equally distributed as the remainder of the edge is closed. Interrupted sutures should be used throughout, preferably about 1/8 inch apart with the knots outside the suture line and one end of the sutures left long to tie across the stent or first layer of gauze.

It may be a temptation to save time by the use of widely spaced interrupted sutures and to finish the closure with a continuous stitch. However, all interrupted sutures picked up in groups of two to four and tied across a stent or gauze pad assure uniform pressure and evenly distributed gentle tension. This results in a better scar line where graft and recipient edge unite; it is well worth the small amount of effort and extra time.

While the surgeon is applying the graft, the gauze bearing the tracing can be used by the nurse as a guide in preparing the dressings which will be used immediately over the graft. Unless a mold or stent of modeling compound is to be a medium of pressure, a pad of gauze should be cut to conform to the graft and to constitute the initial portion of the dressing. Next to the graft there should be a single thickness of fine mesh dry or slightly greasy gauze, which has minimal tendency to adhere to the graft. Then the pad of gauze moistened with normal saline solution is laid on and sutures tied across it, thus establishing uniform and dependable pressure.

If there has been any oozing from the recipient bed, a syringe of saline solution may wash away any clots or thin layer of blood just before the pressure is applied. A coarse needle inserted between the stitches will facilitate this step and cause no loss of time.

A "rope" of moist gauze is wound around and tucked into the small space between the edge of the molded dressing, slightly drawn up by the long ends of sutures tied over it, and the surrounding skin. Moist gauze is more absorbent than dry gauze and obviates the possibility of a dead space or of exudate accumulating, fouling the suture line and permitting stitches to cut in. Larger pads of gauze or mechanic's waste are laid upon the sutured dressing, followed by

additional firm but gentle even pressure assured by taping and elastic or resilient bandages. We have found that bandages prepared by sectioning long rolls of stockinet on a bias are incomparable as a means of providing optimum pressure.

In some locations—as the nose, cheek, upper or lower lip—very bulky dressings are impracticable. In these instances, corset types of dressing are made with strips of adhesive tape upon the neck and cheeks, doubled over at the end closest to the graft and, with a hole through the tape, bandage is tied or laced over the outside covering of the grafted area. In many instances for the nose, lips, or cheek, gauze bandage secured to the ends of the tape and tied behind the neck is helpful.

Pressure is easily procured about the eyes, forehead, or ears by the usual turban type of circumferential bandaging; pressure is accurately gauged by varying the tension on two short strips of gauze laid vertically against the skin preceding the circumferential wrapping; when they are tied around the turban perpendicularly the appropriate amount of pressure is estimated.

Tincture of benzoin applied to skin or to the vermilion edge of a lip will facilitate adhesion of the tape and maintenance of dryness by diverting secretions of the mouth or nose.

Special comment upon eyebrow grafts is fitting at this point. Incidental to treatment of many severe facial burns, this problem has arisen many times. We have stated that the free graft is utterly dependent upon its base, rather than its edges, for nutrition. A probable exception to this is the scalp graft for making an eyebrow. It is a familiar fact that the hair or hair roots within the graft, at the time of transfer, usually are shed. Then a certain per cent of the follicles survive and produce new hair. It is noted that often more hairs survive near the borders of the graft, and a higher per cent survive in a slender graft than in a wide one. Knowing that bold thinning on the deep side of this graft destroys many hair follicle bulbs, we find that less bold thinning and a narrower graft begets a greater per cent of viable follicles. These observations indicate that substantial nutriment reaches the graft from its side. Two or three long narrow grafts, placed side by side at intervals of ten days or more, result in survival of more hairs—especially if the knife blade is inserted into the donor area and drawn parallel to the hair shafts while taking the graft.

## POSTOPERATIVE CARE

Patients having had grafts to the chin or upper or lower lip receive nothing by mouth except liquids through a straw to minimize movement and maintain dryness for about one week. Penicillin, 25,000 units intramuscularly every three hours, is given routinely to all face grafts—and in any other case where local, systemic, or extraneous sepsis might constitute a threat—as an additional measure of precaution against infection. This is given until the time of initial dressing or until aseptic healing is assured. Dressings on face grafts are usually left undisturbed for five days, by which time stitches must be out to avoid marks. During this five-day period, the dressings are checked daily to insure adequate pressure and prevention of soiling from nasal or oral secretions.

Fig. 1.

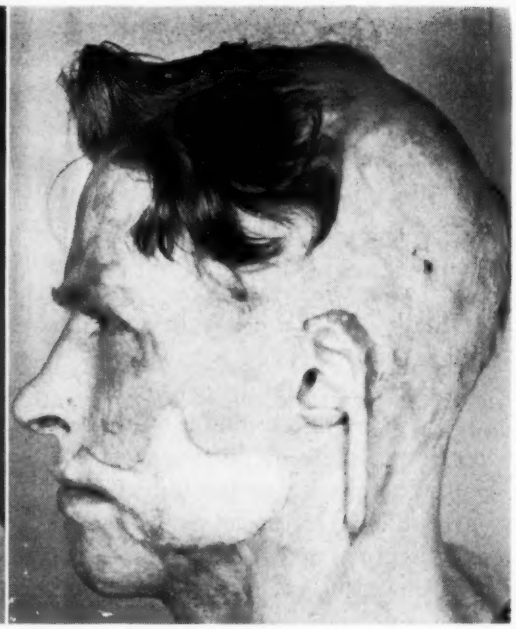

Fig. 2.

Fig. 1.—Severe third degree burns of face imperfectly healed with one split-skin graft and fragile hypertrophied scar.

Fig. 2.—Large Wolfe grafts in cheek, lips, and chin. Ear is being restored with preserved cartilage, split-skin graft behind, and tubed supraclavicular graft.

Fig. 3.

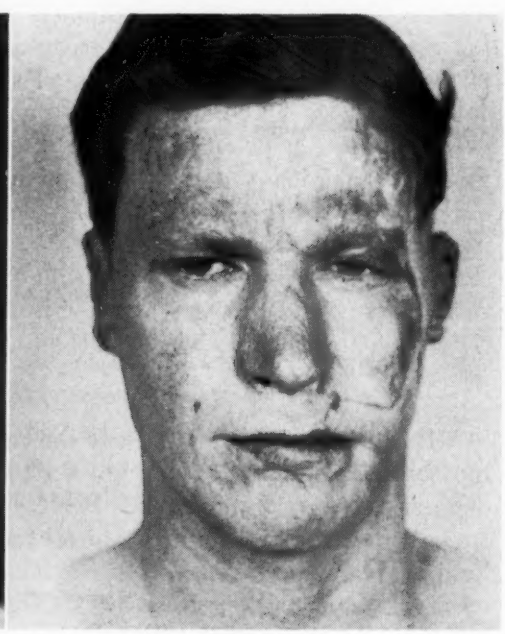

Fig. 4.

Fig. 3.—Characteristic ectropion of lips due to burn contracture.
Fig. 4.—Correction by Wolfe grafts.

Dressings down to those tied directly over the graft may be changed at any time, if necessary to maintain immobility, pressure, and dryness. Elsewhere, as on the hand, dressings upon Wolfe grafts may be left undisturbed for ten days or so.

Early removal of dressings and stitches should be done with the same meticulous care used at the operation in order to prevent any detachment of the graft or separation of its edge. The sutures are cut and teased away from the stent or the gauze, by now firmly molded to the area; then the mold is teased away from the graft, starting at one end. With a forceps holding the mold, the graft can be gently pushed away a bit at a time until separated; disturbance of the graft is thus avoided. This maneuver is facilitated by inserting and opening narrow-bladed scissors between the graft and the gauze. The mold is set aside on sterile gauze for reapplication if it has remained dry and clean; it conforms exactly to the graft and is thus an excellent medium for reapplication of pressure.

All sutures, as a rule, are removed at the initial dressing, especially upon the face, carefully avoiding separation of graft and recipient edge. Edges of the graft are best cleaned with hydrogen peroxide, dried, and 20 per cent mercurochrome solution is applied as a drying and bacteriostatic agent. This is especially important if any moisture is present about the edge. A successful graft at this time presents a pink color.

Reapplication of pressure upon the graft following cleansing and treatment of any complications (to be mentioned later), when present, resembles the original dressing at the operating table. A layer of fine mesh gauze, which does not tend to stick, and the original gauze mold in its exact previous position are replaced. There is no need now for greasy gauze. In fact it is best avoided, because the prolonged presence of a greasy substance encourages maceration and incubates any residual bacteria in a warm, moist, and nutritious medium inevitable in secretions or decomposing tissue. This mold, usually hardened by the serum exuded and original saline solution and capable of re-establishing perfect uniform pressure, is to be reapplied. A strip of tape across it will fix it "home" as gentle but firm pressure is again applied as in the original fixation. These procedures are repeated daily or every other day for a week or two, depending upon how clean and dry the edges are and how the central area is "taking." By then the graft is losing its pinkish hue and taking on the color of the donor site. It will have shrunk to a variable extent and the mold soiled so that it will be discarded. There may be a slight elevation of the scar about the graft where it conformed to the mold and where scar has joined the graft and border of the defect. Fibrosis has, of course, occurred between the graft and its recipient bed; this tends to cause wrinkling of the graft as it undergoes its inevitable shrinking. To minimize the amount of shrinking and to keep the graft permanently flat, pressure must be maintained for at least three or four weeks. The grafts will usually have regained their donor site color by the fourth to fifth week and will often soften sufficiently at the end of six to eight weeks so that it can be determined whether any excision or readjustment of

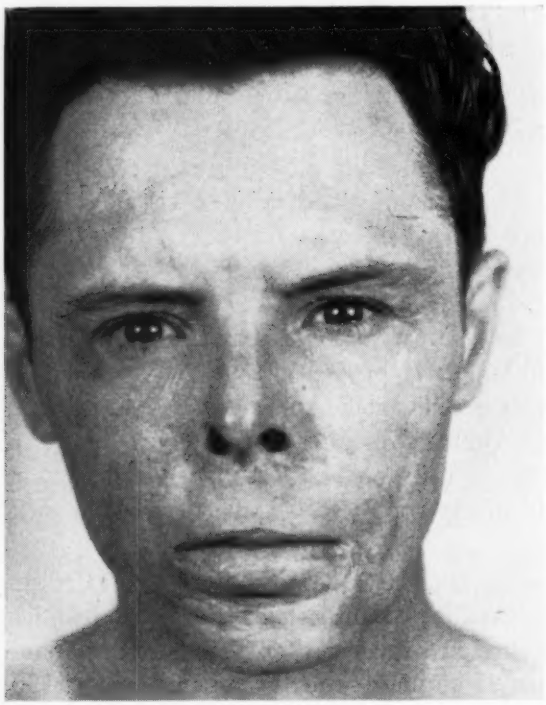

Fig. 5.—Similar case showing relief of ectropion of lips and hypertrophied scar in beard area with three separate Wolfe grafts from clavicular region.

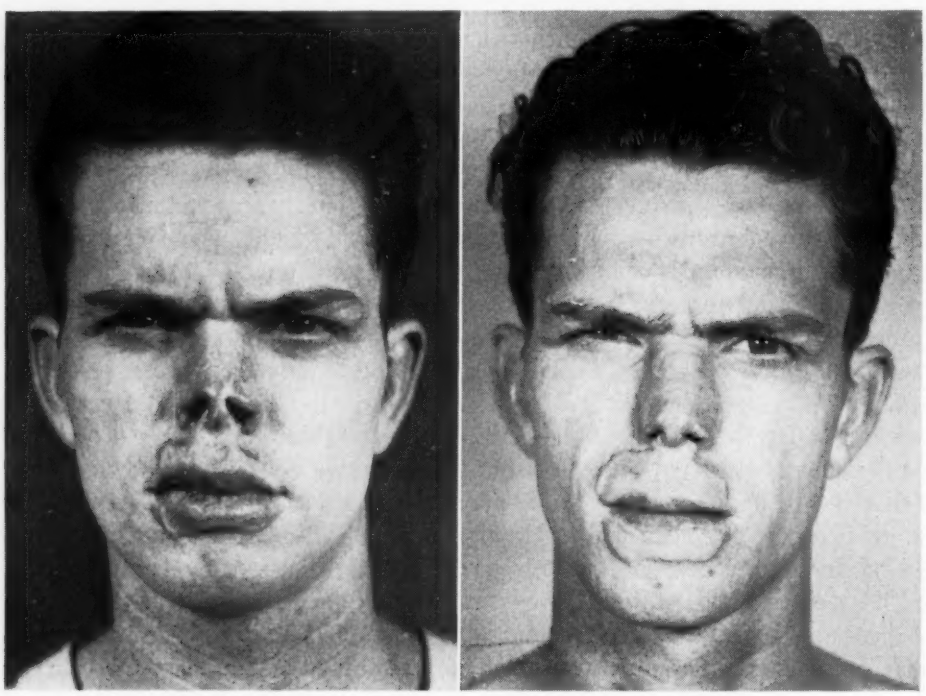

Fig. 6. Fig. 7.

Fig. 6.—Partial destruction of alae and eversion of lips due to burn.

Fig. 7.—Outer alar scarred tissue was turned downward as a lining and entire dorsum of nose grafted. Edges of Wolfe grafts in lips may need revision.

the edges will be necessary. Patients should be told that edges of these grafts may be raised, thickened, or show stitch marks and that a relatively minor secondary surgical procedure will be necessary or, at least, advisable.

## COMPLICATIONS

Complications which may be noted at initial dressing and a method of treating them are as follows:

1. Blebs on the graft surface. These should be gently opened with a sharp blade, fluid expressed, and 20 per cent mercurochrome applied.

2. Separations at the suture line. These can be reapproximated and held in position with strips of flamed adhesive tape, about 1 by ⅛ inch, applied gently directly across the edge.

3. Hematomas under the graft. These usually are indicated by a circumscribed dark red area within the graft, with more or less bulging. If at the edge, it is evacuated by simple expression, reapproximating the edge with flamed adhesive. If the hematoma is not at the edge, it can be evacuated through a stab wound with a bayonet-pointed blade.

4. Serum under the graft. This complication is handled similarly to hematomas. Areas of serous accumulation are denoted by fluctuant bulges with a pale pink or slightly cyanotic hue. The graft is often viable in these areas and there is a good chance that, if the serum is evacuated, this skin may become attached and survive following reapplication of pressure.

5. Areas of necrosis. These, in our experience, are usually small and involve only the superficial portion of the graft. They appear as a demarcated blue or black area along an edge or within the graft. Nothing is to be gained by disturbing them as separation takes place between the eighth to twelfth day, when the superficial necrotic tissue can be dissected off with small scissors, leaving the viable deep surface of the graft; it has the appearance of a pinkish-mottled dermis, closely resembling a skin graft donor site. Our preferred application is a single-ply, fine mesh, scarlet red gauze, over which the usual pressure dressing is reapplied while dry epithelization ensues. This commonly requires at least one week, but sometimes two to four weeks.

Any of these complications can occur during the first two weeks and should be carefully scrutinized and patiently appraised and treated.

6. A remote, unpredictable and uncontrollable complication in some cases is pigmentation of the graft. Why this occurs more in some individuals and, in fact, why it occurs at all is not explained so far as we know. We have noted it more often in dark-skinned individuals and it seems to be permanent. It may be possible that tattooing of these grafts to improve the color matching will be generally available in the near future. Thus far we have had no experience with it but are procuring the equipment for its trial.

## SUMMARY

A review of the technical considerations in Wolfe graft technique has been recorded. No claim is made for originality in any portion of this article. However, the utilitarian value and functional and cosmetic satisfaction of the Wolfe

graft have become more appreciated incidental to the innumerable indications for its use in definitive war surgery.

Since its limitations are so definite, the technique so exacting, and its success so dependent upon observation of the many fine considerations in its management, we feel that a record of observations in 100 or more cases may constitute a helpful guide to those who are interested in application and improvement of this type of graft.

Every step we have considered and each small point that has been discussed is, we believe, important. Omission of any one may cause loss of part or all of a graft, or at least a substandard or disappointing result. Observation of all of them will give the optimum chance for success and encourage greater use of the free full-thickness graft.

# RECURRENT PARATHYROID ADENOMA

## A Case Report

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MANY articles have been published on hyperparathyroidism. Its varied manifestations have been noted and great advance in the pathologic physiology has been made. This report concerns one more variation of the disease. It is believed that this is the first report of a case of recurrent parathyroid adenoma occurring in a glandular graft.

### CASE REPORT

L. R. L., a 31-year-old white newspaper editor, first came to the University Hospital on March 3, 1943. He entered with a chief complaint of "sore knees." He had been in perfect health until one year prior to admission, at which time he experienced the insidious onset of aching in the knees. These symptoms were continuous and progressive in intensity. On the advice of his physician he had all of the upper teeth extracted, which failed to be effective in producing a remission. Eight months later the elbows became similarly affected. Four weeks before he came to this hospital he was pushing a car and quite suddenly had severe pain over the left tibial tubercle. Thereafter, flexion was markedly limited although he was not totally incapacitated. One week later, while walking, the left leg suddenly became very weak and he fell to the ground. The knee became quite swollen and he visited his physician, who aspirated bloody fluid from the knee joint. A roentgenogram of the

TABLE I. SUMMARY OF RENAL FUNCTION

| | URINE | N.P.N.* (MG. %) | B.U.N.† (MG. %) | UREA CLEARANCE (1ST HR.) | UREA CLEARANCE (2ND HR.) | X-RAY |
|---|---|---|---|---|---|---|
| 1943 | Loaded with W.B.C. | -- | 19 | 44% | 31% | Parenchymal calcification |
| 1945 | Same | 62.5 | 39.4 | 28% | 25% | Same |
| 1946 | Same | 51.3 | -- | 71% | 53% | Same |

*Nonprotein nitrogen. †Blood urea nitrogen.

TABLE II. SUMMARY OF BLOOD CHEMISTRY

| | CA (MG. %) | P (MG. %) | ALKALINE PHOSPHATASE* | ACID† PHOSPHATASE |
|---|---|---|---|---|
| 1943 | | | | |
| Preoperative | 15.8 | 4.0 | 19.5 | 6.3 |
| Postoperative | | | | |
| 24 hours | 8.1 | 3.5 | | |
| 48 hours | 10.1 | | | |
| 72 hours | 10.5 | | | |
| 120 hours | 9.9 | 3.0 | | |
| 1945 | | | | |
| Preoperative | 16.0 | 3.5 | 7.8 | 4.6 |
| Postoperative | | | | |
| 24 hours | 11.7 | 3.7 | | |
| 48 hours | 9.8 | 4.0 | | |
| 72 hours | 9.1 | | | |
| 10 months | 9.6 | 2.8 | 2.6 | 3.4 |

*Bodansky units. †King-Armstrong units.

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*Trainee, National Cancer Institute.

knee was made and the patient referred to an orthopedic surgeon. The latter diagnosed the disease correctly and referred him to this hospital.

Systemic review revealed occasional nausea, which the patient believed was due to "nervousness"; once or twice during a nine months' period he vomited. He had no urinary symptoms except for a slight increase in frequency. A twenty-two pound weight loss had occurred in the eighteen months prior to admission. There had been no change in the size of the head as determined by hat size.

Fig. 1.—Lateral skull roentgenogram showing prominence of the trabecular pattern due to demineralization of the bone.

Past history was irrevelant as was the family history except for the death of his mother at the age of 58 years, four months following a goiter operation. The exact cause of death was not known.

Positive physical findings consisted of a very small, firm, nodular mass just to the left of the trachea and just above the top of the sternum. There was a fusiform nontender mass over each tibial tubercle. Both knees were moderately swollen, with evidence of fluid in the joint spaces. There was slight tenderness over the lateral condyles of both elbows.

X-ray examination included a study of the skull, mandible, spine, pelvis, ribs, the long bones, and the knees. The significant findings were:

(1) Prominence of the trabecular pattern and decalcification throughout the entire skeleton. This was especially pronounced in the skull (Fig. 1).

(2) Small cysts in the tibial tubercles bilaterally. There was also a cystic area in the lateral condyle of the left femur. These are shown in Fig. 2.

(3) Cystic lesions were present in the fourth, sixth, and seventh ribs on the right side and in the third rib on the left. Fractures were present through the cystic areas in the posterior axillary line of the sixth and seventh ribs on the right.

(4) There was marked calcium deposition in the parenchyma of both kidneys. In Fig. 3 this calcification is demonstrated to good advantage as well as a large multilocular cyst in the right ilium.

(5) The lamina dura about the teeth was absent.

**Fig. 2.—Anteroposterior and lateral views of the left knee demonstrating typical cystic changes of hyperparathyroidism in the tibial tubercle of the tibia and the lateral condyle of the femur.**

*Significant Laboratory Findings.*—The serum calcium was 15.8 mg. per cent while the inorganic phosphorus was 4.0 mg. per cent. Alkaline phosphatase was 19.5 Bodansky units and the acid phosphatase was 6.3 King-Armstrong units. The urine was loaded with white blood cells. While there was moderate impairment of renal function by the urea clearance test (Table I), the blood urea nitrogen was within normal limits. The Sulkowitch test showed a four plus reaction for calcium excretion.

The diagnosis of hyperparathyroidism probably due to a parathyroid adenoma was apparent and on March 13, 1943, ten days after admission, operation was performed. A tumor mass measuring 2½ by 2 by 2 cm. was found in the position of the parathyroid beneath the lower pole of the left lobe of the thyroid. The mass was completely excised

but, since a hypoparathyroid state postoperatively was feared, a small fragment was transplanted between the sternothyroid and sternohyoid muscles.

Postoperatively he was placed on a high calcium intake, both orally and intravenously, and was given prophylactic doses of dihydrotachysterol. In twenty-four hours the serum calcium fell from the preoperative level of 15.8 to 8.1 mg. per cent (Table II). The second day the serum calcium was 10.1 mg. per cent and thereafter remained normal. The patient never developed definite signs of tetany postoperatively, although he frequently complained of numbness of the entire body and especially of the fingers. He was discharged on the eleventh postoperative day on a high calcium intake.

Fig. 3.—Deposition of calcium phosphate in the parenchyma of the kidneys, showing typical renal involvement in hyperparathyroidism.

Unfortunately the patient failed to report for checkup examination until two years later, at which time he was again hospitalized. History at that time revealed that he had continued to improve postoperatively until three or four months before this second admission. During that time he had increasing fatigue, constipation, headache, occasional nausea and vomiting, nervousness, and insomnia. There had been some aching in the back, the right shoulder, and lower extremities. He had lost approximately eight pounds in the preceding month.

Examination revealed a firm palpable mass in the left side of the neck approximately 1½ cm. in diameter. The serum calcium was 16.0 mg. per cent and the inorganic phosphorus

was 3.5 mg. per cent. Alkaline phosphatase was 7.8 Bodansky units and acid phosphatase was 4.6 King-Armstrong units. The urinalysis was the same as on the previous admission; there was further impairment of renal function and the blood urea nitrogen was 39.4 mg. per cent.

X-ray examination revealed destructive lesions in both iliac bones. In the multilocular cysts there were areas which showed definite evidence of repair since 1943, while other areas showed progression in the extent of destruction. The flat plate of the abdomen showed the same extensive calcification. There was irregularity in the distal ends of both clavicles, possibly the results of bone destruction.

The diagnosis of a recurrent parathyroid adenoma producing hyperparathyroidism was made, and on March 16, 1945, operation was performed. At operation a firm gray tumor mass was found in the sternothyroid muscle. The mass was completely excised and was found to measure 2.5 by 2 by 1.5 cm.

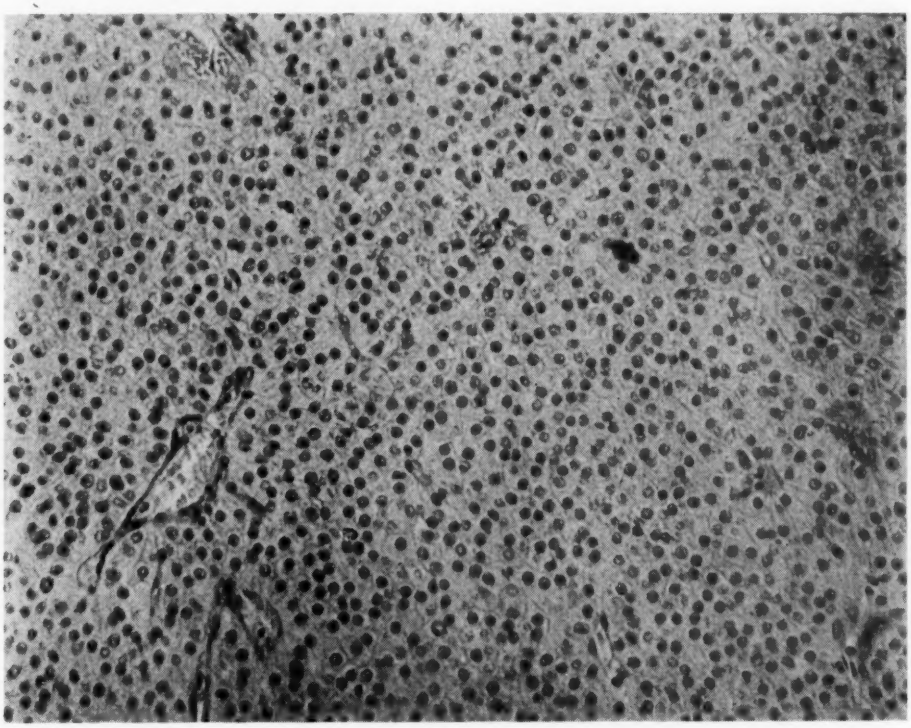
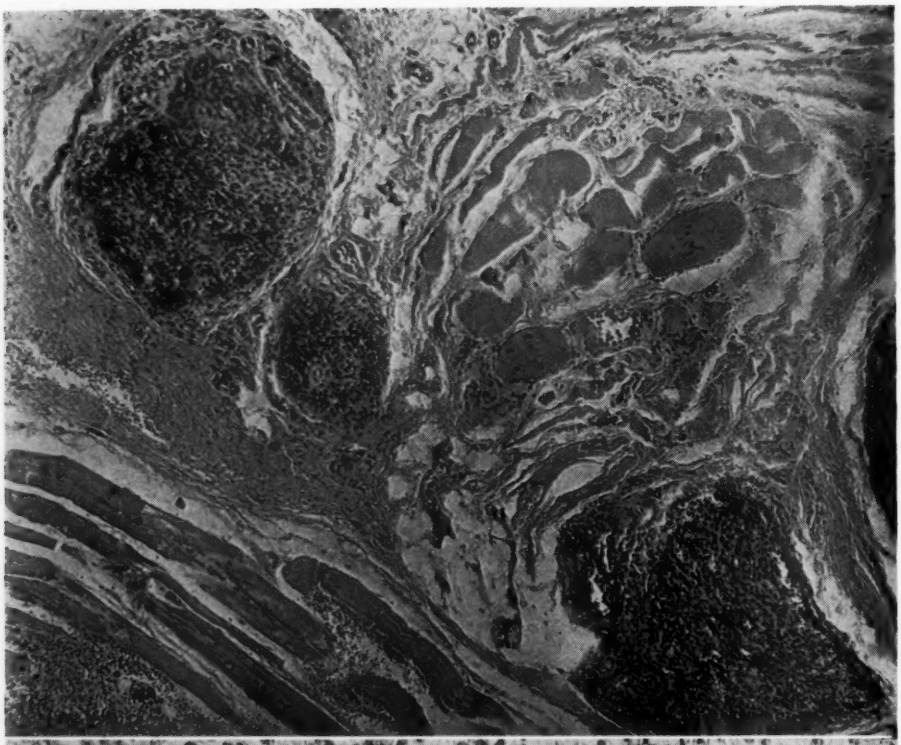


Fig. 4.—Microscopic section of the primary adenoma of the parathyroid (×300).

Postoperatively the first day, the serum calcium dropped to 11.7 mg. per cent. The second postoperative day was 9.8 mg. per cent and on the third day it was 9.1 mg. per cent. No intravenous calcium was given. The patient was placed on a high calcium diet with calcium supplements orally. No dihydrotachysterol was administered. He developed no definite signs of tetany but again had episodes of numbness of the arms and hands. He was discharged from the hospital on the fourth postoperative day with instructions to continue the high calcium intake.

The patient has reported that the paresthesia was present for ten days postoperatively and after that time did not recur. He was seen on Jan. 11, 1946, for checkup examination. At that time he was asymptomatic and there were no positive physical findings of significance. There was no evidence of a recurrent tumor in the neck and the blood chemistry findings were normal (Table II). The Sulkowitch test on the urine showed a two plus reaction for calcium. While renal function had apparently improved as evidenced by the urea clearance test (Table I), the nonprotein nitrogen in the blood was slightly elevated and the urine

Fig. 5.



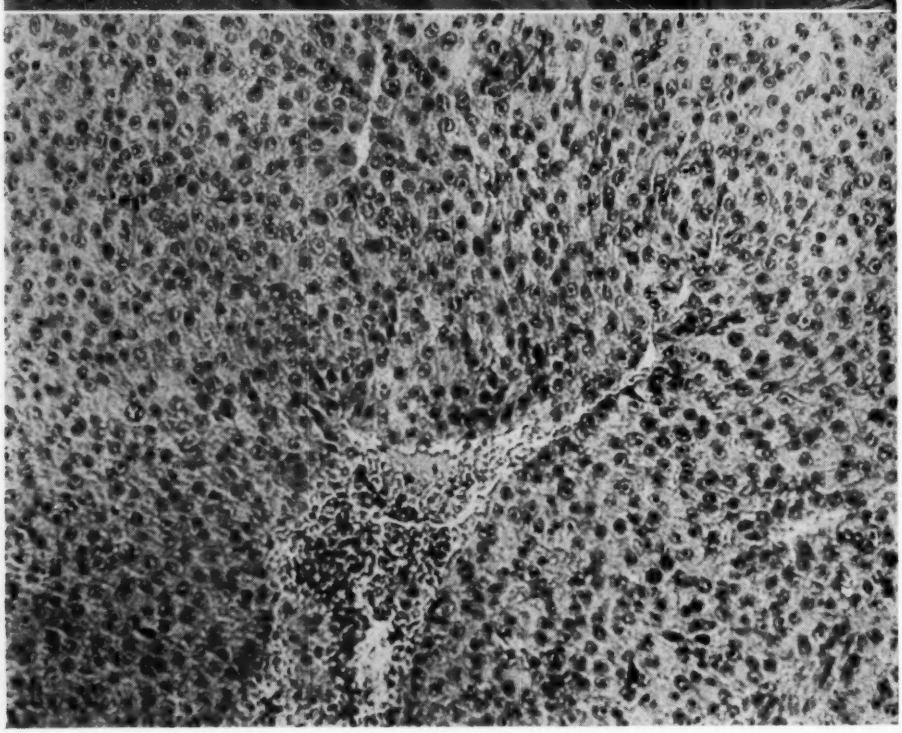


Fig. 6.

Fig. 5.—Microscopic section of recurrent parathyroid adenoma. Note the adenomatous tissue between the bundles of striated muscle (×100).

Fig. 6.—Microscopic section of recurrent parathyroid adenoma (×300).

showed it to be loaded with white blood cells without the presence of organisms. He has been advised to have further urologic investigation.

X-ray examination showed complete recalcification of the skull and partial remineralization of the cervical spine. The cystic areas were nearly recalcified. In this regard the alkaline phosphatase was normal. A scout film of the abdomen revealed the tubular calcification to be unchanged, and, of course, it is extremely doubtful that this will ever significantly improve.

*Pathologic Report.—*

*Primary tumor:* The tumor mass measured 2½ by 2 by 2 cm. It was a large parathyroid adenoma showing areas of sclerosis and calcification. In a few areas there were eosinophilic cells and there were areas of old hemorrhage. Along one border there was a small amount of thyroid tissue. There was some indication that this adenoma may have penetrated its capsule. This is mentioned to call attention to the possibility of local recurrence (Fig. 4).

*Recurrence:* A large adenoma of the parathyroid was found in which there was variation of cell type, there being both small, dark chief cells and larger "wasserhelle" cells. Connective tissue trabeculae and many large blood spaces were found within the adenoma but there was no necrosis. There was abundant old hemorrhage, both within and surrounding the adenoma. The adenomatous tissue was not encapsulated, some of the lobules extending between bundles of striated muscle. Some of the cells of the adenoma were atypical in respect to shape and nuclear content. In general this recurrent adenoma was similar to that removed two years ago except that foci of eosinophilic cells were absent in this present specimen, and sclerosis was less marked (Figs. 5 and 6).

## DISCUSSION

The clinical manifestations in both instances were typical of hyperparathyroidism and require no special comment. On the other hand, there are several pathologic aspects of this case which should be emphasized.

First of all, the capsule of the primary tumor had been penetrated and the possibility of recurrence suggested. This failed to occur at the site of the original tumor. Instead, recurrence apparently occurred as the result of proliferation of the transplant with a return of the manifestations of hyperparathyroidism.

Second, the original tumor was pathologically a parathyroid adenoma, which, of course, is no longer a medical oddity; it presented no characteristics of malignancy except for penetration of the capsule. On the other hand, in the recurrent tumor some of the cells were less typical, there was no encapsulation, and strands of cells were found between muscle bundles. The pathologists at the University Hospital are of the opinion that this tumor should not be diagnosed as carcinoma. While there are mild pleomorphic and hyperchromatic changes in some of the cells, the tumor is still of a well-differentiated type. The intermingling of tumor and muscle need not imply invasive growth since the transplant could not have had a limiting capsule on all sides.

## SUMMARY

A case report is presented of a patient who had a parathyroid adenoma. At operation a fragment of the adenoma was transplanted between the strap muscles of the neck. Two years later the patient returned with a recurrence of all manifestations of hyperparathyroidism and a recurrent adenoma at the site of the graft. Pathologically, neither tumor was considered malignant.

# THE EFFECTS AND DRAWBACKS IN THE USE OF HEPARIN IN RETARDING MENSTRUUM

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THE use of anticoagulant therapy in the treatment and prevention of thrombo-embolic diseases[2-4, 9-12] as well as in the treatment of frostbite[5, 6] is becoming more widespread as time passes. While dicumarol can be taken orally it has the distinct disadvantages of having a rather extensive time lag between administration and anticoagulant action and of offering considerable difficulties in predicting proper dosage in each individual case. These difficulties make it impossible to use the drug where an immediate and predictable effect on the clotting mechanism is desired.

Heparin, however, which does not have these disadvantages must be administered intravenously, preferably by intravenous drip, and its use is rather costly. It is, therefore, understandable that any method obviating these difficulties by the use of a retarding menstruum would be a distinct step forward. Loewe and his collaborators[8] have used heparin in Pitkin's menstruum subcutaneously in a series of rabbits and described satisfactory results. They describe even and prolonged elevations of the clotting time for long periods of time after one deposition of the preparation. Later, two of these authors[7] reported favorable results in fifteen cases of thrombophlebitis. Bryson and Code[1] obtained elevations of the clotting time for from seventeen to seventy hours in dogs by means of heparin in a beeswax mixture injected intramuscularly.

During the course of certain experiments on the prevention of gangrene subsequent to frostbite by the use of heparin, we found it necessary to search for a method by which heparin could be administered in single injections to experimental animals. The effect was supposed to be a long-lasting, predicable, and even elevation of the clotting time as one would desire it for use in patients. One hundred seventy-five rats and forty-five rabbits were used in the different phases of these experiments. Two preparations* were utilized in these experiments based on the suggestion of Loewe using heparin in Pitkin's menstruum. The composition of the two preparations, which differ only by way of the vasoconstrictor added to one of them, is shown in Table I.

The work described in this paper was done under a contract between the Committee on Medical Research and Development and the New York Medical College.

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*We are greatly indebted to Dr. W. T. Strauss of Roche-Organon, Inc., Roche Park, Nutley, N. J., for supplying us with ample quantities of heparin in Pitkin's menstruum in its various forms.

TABLE I. COMPOSITIONS OF LP 9 AND LP 10

| | LP 9 (MG.) | LP 10 (MG.) |
|---|---|---|
| Crystallized sodium salt of heparin | 100.0 | 100.0 |
| Chlorbutanol | 0.5 | 0.5 |
| Eucupine dehydrochloride | 1.0 | 1.0 |
| Epinephrine hydrochloride | 1.0 | |
| Ephedrine sulfate | 25.0 | |
| Pitkin's menstruum (q.s. ad) | 2.0 c.c. | 2.0 c.c. |

The addition of a vasoconstrictor to preparation LP 9 further contributes to the slow absorption of the heparin. Clotting times were determined by the Lee-White modification of Howell's method performed on heart blood in both rats and rabbits. The normal clotting time in rats by this method is between 2½ and 9 minutes; in the rabbit between 4 and 12 minutes.

A single subcutaneous deposition of 0.1 c.c. of the preparations LP 9 and LP 10 in rats results in a marked elevation of the clotting time for at least twelve hours, but of a rather uneven character. The beginning of the prolongation occurs considerably earlier with the preparation without vasoconstrictor than it does with the other. In general, it was our impression that preparation LP 10 (without vasoconstrictors) gives a more rapid effect but does not last so long as a deposition of LP 9 (with vasoconstrictors). None of the preparations produces an even prolongation of the clotting time during the period of its effectiveness (Table II).

TABLE II. AVERAGE CLOTTING TIMES OBTAINED IN FORTY RATS AT VARIOUS INTERVALS AFTER A SINGLE SUBCUTANEOUS INJECTION OF LP 9 AND LP 10

| AMOUNT INJECTED | CLOTTING TIMES AFTER: 2 HR. | 4 HR. | 8 HR. | 12 HR. | 24 HR. |
|---|---|---|---|---|---|
| 0.1 c.c. LP 9 | | Normal | Over 4 hr. | 45 min. | Normal |
| 0.1 c.c. LP 10 | | Over 4 hr. | 60 min. | 30 min. | Normal |
| 0.2 c.c. LP 9 | Normal | Over 24 hr. | Over 24 hr. | 8 hr. | |
| 0.2 c.c. LP 10 | Over 18 hr. | 12 hr. | 12 hr. | 12 hr. | Normal |

In order to obtain a rapid rise in clotting time as well as a prolonged action, both preparations should be injected at different sites since mixture of them in one deposition does not produce the desired effect (Table III).

While single injections produced a marked although not quite satisfactory response, because of the uneven characteristics of the curve of the clotting time, repeated injections in the same animal introduced serious complications. At the site of the second or subsequent depositions invariably huge hematomas formed as well in rats as in rabbits. Frequently these hematomas are so large that the animal actually dies from exsanguination. Many others showed definite signs of severe anemia. Of forty-nine rats receiving daily subcutaneous injections for five days, eighteen died spontaneously. All animals autopsied showed very large subcutaneous hematomas and signs of severe anemia and no other cause of death. The remaining thirty-one were sacrificed for various reasons. Of these, twenty-three were autopsied, nineteen showing large subcutaneous hematomas. These hematomas were occasionally so large that they trapped the heparin given in subsequent injections, causing an insufficient elevation of the clotting time.

TABLE III. THE ACTION OF COMBINATIONS OF LP 9 AND LP 10 WHEN INJECTED IN THE SAME AND DIFFERENT SITES (SIXTEEN RATS)

| AMOUNT INJECTED | CLOTTING TIMES AFTER: 2 HR. | 4 HR. |
|---|---|---|
| 0.1 c.c. LP 9 + 0.1 c.c. LP 10 in same syringe | Normal | 15 min. |
| 0.1 c.c. LP 9 + 0.1 c.c. LP 10 in different sites | 30 min. | Over 2 hr. |

These difficulties, in so far as the rat is concerned, are largely obviated by injecting subcutaneously into the tail. Here the skin is firmly bound down to the subcutaneous tissues, effectively preventing the formation of large hematomas. Of fifty-one rats thus treated, only thirteen died and the remainder were adequately heparinized for the desired period of time.

The rats which died after injection into the tail, moreover, all died within one-half hour after injection, many with convulsions and gross bleeding from the nose and mouth. Autopsy on eleven of these showed multiple fresh pulmonary infarctions, indicating that the Pitkin's menstruum had found its way directly into a vein. That this is a relatively infrequent accident is indicated by the fact that out of a total of more than 150 tail injections given it occurred only thirteen times. Gangrene of the tail frequently developed in rats thus treated due to interference with the circulation, but this does not interfere with the treatment if each injection is made proximal to the preceding one.

Forty-five rabbits were heparinized by the subcutaneous route using the preparations LP 9 and LP 10 or combinations of both. All of them, as far as they were autopsied, showed huge hematomas at the site of the second and subsequent injections and many had signs of a severe anemia.

In human beings hematomas probably occur at the site of injections indicated by intense pain lasting for many hours, but they are comparatively innocuous due to the different relation between the size of the hematoma and the total blood volume. Moreover it has been our experience that approximately 50 per cent more heparin is needed in human beings when given by subcutaneous deposition than by intravenous drip. However, patients who have already suffered blood loss, as well as anemic patients, should be watched carefully and transfusions given immediately if signs of further blood loss should appear.

## SUMMARY AND CONCLUSIONS

1. The value of prolonged heparinization is discussed briefly and the literature on retarding menstrua reviewed.

2. Although the clotting times obtained after a single deposition of heparin in Pitkin's menstruum shows considerable spikes, a satisfactory elevation can be produced for twenty-four hours with large doses in experimental animals.

3. In small animals *repeated* subcutaneous administration of heparin in Pitkin's menstruum leads to the formation of large hematomas which not only trap the heparin and prevent adequate heparinization but frequently cause the death of the animal.

4. These difficulties are overcome in the rat by injection into the tail.

5. In human beings the small size of hematomas compared to the total blood volume probably renders them less important but great care should be exercised in anemic patients.

REFERENCES

1. Bryson, J. C., and Code, C. F.: Prolonged Anti-Coagulant Action of Heparin in Beeswax Mixture, Proc. Staff Meet., Mayo Clin. **19**: 100, 1944.
2. Evans, J. A.: Orientation of Treatment in Thrombophlebitis, Phlebothrombosis and Pulmonary Embolism, Ann. Int. Med. **17**: 970, 1942.
3. Klien, B.: Anticoagulant Therapy of Occlusion of Central Vein of Retina in Relation to Pathogenesis and Differential Diagnosis, Arch. Ophth. **29**: 699, 1943.
4. Lam, C. R.: Anticoagulants—Heparin and Dicumarol, J. Michigan M. Soc. **42**: 968, 1943.
5. Lange, K., and Boyd, L. J.: The Functional Pathology of Frostbite and the Prevention of Subsequent Gangrene, Surg., Gynec. & Obst. **80**: 346, 1945.
6. Lange, K., Boyd, L. J., and Loewe, L.: The Functional Pathology of Frostbite and the Prevention of Gangrene in Experimental Animals and Humans, Science **102**: 151, 1945.
7. Loewe, L., and Rosenblatt, P.: A New Practical Method for Subcutaneous Administration of Heparin, Am. J. M. Sc. **208**: 54-63, 1944.
8. Loewe, L., Rosenblatt, P., and Lederer, M.: A New Method of Administering Heparin, Proc. Soc. Exper. Biol. & Med. **50**: 53-55, 1942.
9. Luke, J. C.: Mesenteric Venous Thrombosis: Treatment With Heparin, Lancet **1**: 552, 1943.
10. Murrary, G. D. W.: Heparin in Surgical Treatment of Blood Vessels, Arch. Surg. **40**: 307, 1940.
    Idem: Heparin in Thrombosis and Embolism, Brit. J. Surg. **27**: 567, 1940.
11. Rabinovitch, J., and Pines, B.: Effect of Heparin on Experimentally Produced Venous Thrombosis, SURGERY **14**: 669, 1943.
12. Rosenthal, C. M., and Gusek, J. T.: Thrombosis of Central Retinal Vein Treated Successfully With Heparin: Report of 2 cases, Arch. Ophth. **30**: 232, 1943.
13. Walker, J., Jr.: The Efficacy of Heparin Administered by Intravenous, Intramuscular and Subcutaneous Routes, and a Study of the Effect of Five Bacteriostatic Agents on Heparin Action, SURGERY **17**: 54-60, 1945.

# TANTALUM SCALP SUTURES

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THE method of suturing the scalp has changed very little during the period of development of neurosurgery. The two-layer technique (Fig. 1), using silk in the galea and skin, has become universally accepted. Slight variations, such as continuous silk or dermal in the skin, have been advocated by some surgeons, but most have adhered to the principle of closing the scalp in two layers. Babcock popularized the use of stainless steel as a suture material. Cone has used for years a vertical mattress stitch of this material in closing craniotomy wounds. This method probably is employed by other surgeons.

The two-layer technique produces excellent wounds but does possess several disadvantages. A large amount of foreign material is buried in the scalp, adding a potential source of infection. Even without infection the sutures may produce a point of local irritation in the scalp and necessitate removal. It is not uncommon, even many months after operation, to have a patient complain of catching the teeth of a comb in an old suture that has worked to the surface.

The two-layer technique is a tedious procedure which consumes unnecessary time at the end of the operation when the general condition of the patient may be the cause of some concern. Furthermore, during the additional time of closure a far greater amount of blood is lost than is generally appreciated. Because of these factors, it semed worth while to investigate other methods that were more rapid and did not leave buried suture material in the scalp.

It has been a common practice to use a single layer of interrupted heavy silk sutures for secondary closure of a craniotomy. This saved much time and produced satisfactory results. It seemed logical to adapt this procedure to the primary closure of scalp wounds. We used silk at first, but found that through-and-through sutures placed some distance from the scalp edge tended to evert the edges and did not produce the desired fine line of healing. If this method of suture were converted into a mattress type, returning through the scalp a few millimeters from the margins, accurate approximation was obtained but reaction and often minute stitch infection occurred. These features were objectionable, and the method was not used routinely even though mechanically satisfactory.

The introduction of tantalum afforded a material which produced no tissue reaction.[1, 2] It is used extensively as a nerve suture material and should be equally effective in the scalp. During the past year interrupted mattress sutures of fine tantalum wire (0.007) have been used to close all craniotomy

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wounds. The deep loop of the suture passes through the galea about 1 cm. from the edge and the superficial portion is through the cutaneous surface as near the free margins as possible (Fig. 2). In this manner skin and galea are accurately approximated and excellent healing is obtained (Fig. 3).

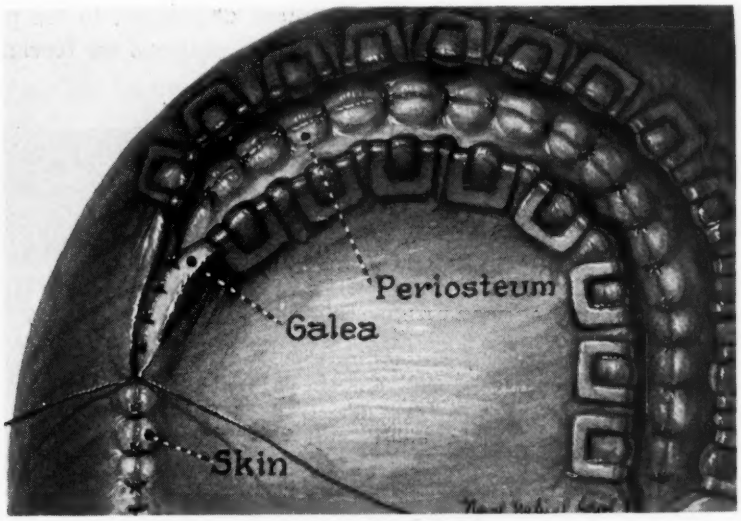


Fig. 1.—The usual two-layer technique of scalp suture with interrupted silk sutures in both galea and skin.

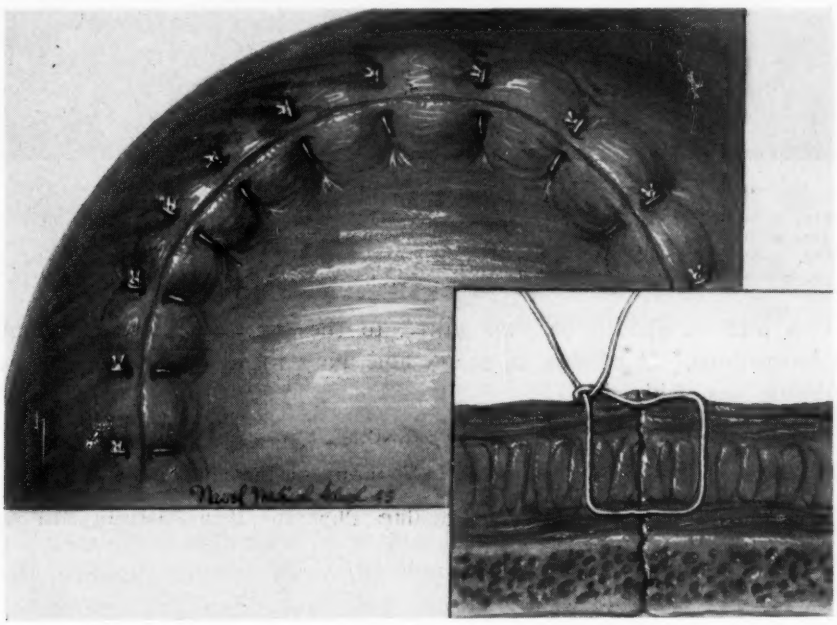

Fig. 2.—Accurate closure with single layer of tantalum wire mattress sutures.

It is desirable to leave the cut ends of the wire long enough so that they can be easily identified later, since the scalp reaction is so minimal that some may be overlooked in removing if the ends are cut too short.

An added feature is the fixation of the dressing. The gauze mesh is held by the cut ends of the wire so that the gauze placed directly on the suture line is accurately held, thus preventing the dressing from sliding back and forth. This may be as important as the application of wound towels during the operation.

The wire sutures are easily removed without discomfort to the patient and the ultimate result is a well-healed wound which contains no foreign material (Fig. 4).

Fig. 3.

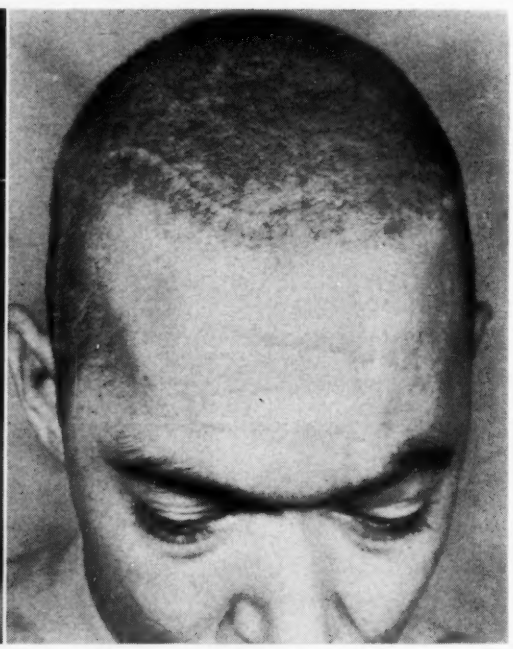

Fig. 4.

Fig. 3.—Tantalum wire sutures, ten days after operation. There is minimal reaction about the sutures and excellent approximation of wound edges.

Fig. 4.—Photograph of healed craniotomy incision. All foreign material is removed from the scalp.

This method should be well suited to the primary closure of traumatic scalp lacerations. It affords an easier and more rapid method of closure with a minimum loss of blood.

## REFERENCES

1. Burke, D. L.: The Corrosion of Metals in Tissues: An Introduction to Tantalum, Canad. M. A. J. 43: 125-128, 1940.
2. Pudenz, Robert H.: The Use of Tantalum Clips for Hemostasis in Neurosurgery, SURGERY 12: 791-797, 1942.

# A NEW SUCTION TUBE FOR CHEST AND ABDOMINAL OPERATIONS

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FOR a number of years a modification of the Pool abdominal suction tube has been in use on the surgical clinic service at Stanford University Hospital. It was primarily designed for operations within the chest, but it is equally useful in abdominal procedures.

The new tube is interchangeable with the conventional Pool tube so that either one may be used during an operation without disconnecting the suction. The cap is eccentrically placed so that suction may be used on the sides of the chest or abdominal wall, as well as on the bottom of the cavity. The cap is also detachable, which facilitates cleaning.

Fig. 1.

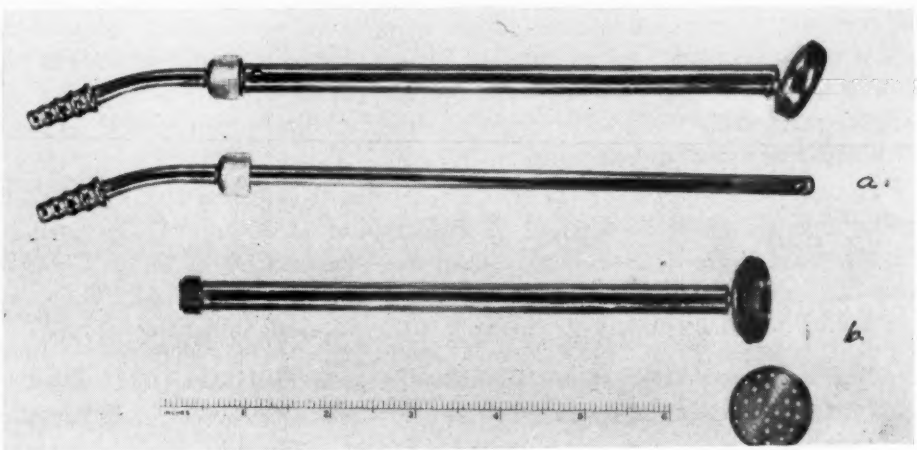


Fig. 2.

Fig. 1.—The assembled tube.
Fig. 2.—*a*, Pool handle, *b*, new tube with detachable cap.

The new tube* has the advantage of the suction being applied to the end of the instrument rather than along the sides, as in the Pool tube. This permits the complete aspiration of pockets of blood and exudate. Clots and fibrin can be removed with ease from the smooth surfaces of the abdominal and chest walls. Whenever possible, suction is used instead of sponging thereby lessening the amount of trauma, with resultant prevention of adhesions.

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*The tube may be obtained from V.. Mueller & Company, 408 South Honore Street, Chicago 12, Ill.

# Recent Advances in Surgery

Conducted by Alfred Blalock, M.D.

## INTESTINAL OBSTRUCTION DUE TO PERFORATIONS OF THE GALL BLADDER

### An Analysis of Forty-One Cases of Perforated Gall Bladder in Eleven of Which There Was Associated Intestinal Obstruction

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GALLSTONE ileus, the result of perforations of the gall bladder into the intestinal tract, has received much attention in the literature. We have been able to find nothing in the literature which draws attention to the relation of other types of gall bladder perforation to intestinal obstruction. Since in this present study, perforations of the gall bladder without fistula formation have resulted in over one-half of the intestinal obstructions in our total series, it is thought worth while to draw specific attention to the inflammatory results of gall bladder perforation as a cause of intestinal obstruction.

The surgical records for the past twenty years (1926 to 1945) and all the autopsy records since the opening of this hospital (1889 to 1945), a period of fifty-five years, have been searched for cases of perforation of the gall bladder. Forty-one cases were found, exclusive of those on a traumatic basis. These cases have been divided according to Niemeier's classification into three groups:

Type I (Acute free perforation into the peritoneal cavity), 13 cases
Type II (Subacute perforation with pericholecystic abscess), 15 cases
Type III (Perforation into a viscus), 13 cases

Of the eleven cases in this series in which intestinal obstruction was an associated factor, five patients (38 per cent) were seen with type I perforations, one (7 per cent) with type II perforations, and five (38 per cent) with type III perforations.

In the last group the five cases of obstruction were due to the extrusion of gallstones into the intestinal tract with resultant "gallstone ileus." The other eight cases of type III perforation, although associated with cholecystenteric fistulas, did not result in gallstone obstruction. The obstructions associated with the other types of gall bladder perforation either were paralytic in nature due to generalized peritonitis or were due to pressure on some portion of the intestinal tract by an inflammatory mass. The fact that in too many instances the

obstructive symptoms either overshadowed the symptoms of cholecystitis with perforation or confused the diagnosis made us decide to put this analysis of our cases on record.

## GENERAL CONSIDERATIONS

*Incidence of Gall Bladder Perforations.*—Our series of forty-one perforations of the gall bladder represents all those available in the surgical records of the Johns Hopkins Hospital for the twenty-year period, January, 1926, to January, 1945, plus all the autopsy material from 1889 to January, 1945 (a period of fifty-five years). During the periods stated there were 11,794 gall bladder operations in which the incidence of perforation was 0.3 per cent (twenty-nine cases) and there were 19,274 autopsies in which the incidence of gall bladder perforation was 0.01 per cent (seventeen cases). Twelve of the cases in this series were counted under both headings. All of the 735 gall bladder operations at this hospital from 1889 to 1924 have been analyzed by Blalock (1924). In this group there was one cholecystenteric fistula and there were nineteen cases of peritonitis due to gall bladder disease.

Cowley and Harkins (1943) found an average incidence of 2.8 per cent perforations in 12,915 reported operations on the gall bladder. The lowest incidence of perforation (0.9 per cent) was in their series of twenty-five cases reported at Henry Ford Hospital. The highest incidence, 12.1 per cent, was reported by Mentzer (1936). On the other hand, when only cases of acute cholecystitis are considered, the incidence is higher. Cowley and Harkins (1943) reported an average incidence of 13.0 per cent in a collected series of 2,261 cases of acute cholecystitis. Hicken and Coray (1943) reported that their twenty-four cases of gall bladder perforation represent "25.6 per cent of all the 'acute gall bladders' operated upon."

*Mortality From Free Perforations of the Gall Bladder.*—In the group of nine patients operated upon (Tables I, II, and III) there were five deaths (55 per cent mortality). In this group, two cases (Cases 3 and 5) were diagnosed correctly and the patients underwent cholecystectomy. One of these died on the second postoperative day of a cerebral vascular accident associated with a complete right hemiplegia. The other died on the fourth postoperative day with what proved to be at autopsy a rupture of the left ventricle. Another patient

TABLE I. MORTALITY OF SURGICAL CASES OF FREE AND LOCALIZED PERFORATIONS OF THE GALL BLADDER

| AUTHOR | FREE PERFORATIONS | | LOCALIZED PERFORATIONS | |
|---|---|---|---|---|
| | NUMBER OF CASES | PERCENTAGE MORTALITY | NUMBER OF CASES | PERCENTAGE MORTALITY |
| Niemeier (1934) | 2 | 0 | 6 | 0 |
| Sanders (1937) | 4 | 50 | 42 | 14 |
| Pennoyer (1938) | 7 | 100 | -- | -- |
| Stone and Douglas (1939) | 6 | 0 | 11 | 9 |
| Hotz (1939) | 53 | 36 | 16 | 0 |
| Atlee and Atlee (1941) | 4 | 50 | 11 | 9 |
| Glenn and Moore (1942) | 3 | 67 | 22 | 5 |
| Schaeffer (1942) | 14 | 43 | 6 | 33 |
| Cowley and Harkins (1943) | 6 | 17 | 18 | 17 |
| Blain and Harkins (1946) | 9 | 55 | 20 | 15 |
| Total or average | 108 | 42 | 152 | 10 |

TABLE II. NIEMEIER TYPE I PERFORATIONS

| NO. | TYPE OF PERFORATION | AGE, RACE, AND SEX | PREOPERATIVE DIAGNOSIS | OPERATION |
|---|---|---|---|---|
| | | | | *Surgical* |
| 1 | Generalized bile peritonitis | 53, W., F. | Acute pancreatitis | Exploratory laparotomy, cholecystectomy, and drainage of peritoneal cavity |
| 2 | Generalized purulent and bile peritonitis | 40, W., F. | Acute exacerbation of chronic cholecystitis with lithiasis; no mention of perforation | Drainage of perforated gall bladder (cholecystostomy) |
| 3 | Generalized purulent peritonitis | 74, W., F. | Perforation of gall bladder | Cholecystectomy |
| 4 | Generalized bile peritonitis | 46, W., M. | Acute exacerbation of chronic cholecystitis with cholelithiasis; paralytic ileus | Drainage of gall bladder region; gallstones and bile in general peritoneal cavity |
| 5 | Generalized bile peritonitis | 67, N., M. | Acute cholecystitis with perforation resulting in generalized peritonitis | Cholecystectomy and drainage |
| 6 | Acute cholecystitis; localized abscess which had ruptured with generalized peritonitis and multiple ileocecal and pelvic abscesses | 64, W., M. | Partial intestinal obstruction and acute abdominal condition | Exploratory laparotomy and drainage of abscess in right inguinal region; later, enterostomy on ward for intestinal obstruction |
| 7 | Generalized bile and purulent peritonitis (loosely walled off by omentum and transverse colon) | 77, W., F. | Acute pyelonephritis and acute cholecystitis with cholelithiasis | Cholecystostomy with drainage (exploratory laparotomy over palpable mass) |
| 8 | Type I. Acute free perforation with escape of bile down paracolic gutter | 47, W., M. | Intestinal obstruction due to inflammatory or neoplastic cecal mass (acute complete) | Exploratory laparotomy; terminal ileostomy for probable neoplasm at cecum |
| 9 | Acute free perforation | 60, W., F. | Acute appendicitis (retrocecal?) | Cholecystectomy with drainage |
| | | | | *Autopsy Cases* |
| 10 | Generalized purulent and bile peritonitis | ?, F. | Typhoid fever (1901) | No operation |

(ACUTE FREE PERFORATION)

| RESULT | STONES | BACTERIOLOGY | PATHOLOGY |
|---|---|---|---|
| *Cases* | | | |
| Well | + | *Staph. aureus* hemolyticus | Friable ruptured gall bladder removed at operation |
| Well | + | Gall bladder, no growth in 72 hr. | Ruptured gall bladder drained but not removed |
| Died (ruptured heart); (autopsy) | + | Gall bladder and general peritoneal cavity, *Esch. coli* (heavy growth), and gamma str. (light growth) | Cholelithiasis, ulcerative cholecystitis with thrombosed arteries and veins in wall of gall bladder |
| Well (returned one year later with symptoms; refused to be admitted) | + | Peritoneal cavity, no growth on blood agar or in broth | Ruptured gall bladder drained but not removed |
| Died (cardiovascular accident?); (no autopsy) | + | Gall bladder, alpha str.; peritoneal cavity, light growth of gamma str. | Chronic ulcerative cholecystitis with perforation, scarring, and peritonitis; several necrotic areas in wall which is densely infiltrated with P.M.N.s. |
| Died (autopsy) | Mass of inspissated bile | Cultures of abscess, *B. coli* | Gangrenous cholecystitis, rupture of gall bladder with formation of a large abscess in part of right lumbar region and many small abscesses in ileocecal region and pelvis; chronic adhesive peritonitis, acute catarrhal enteritis |
| Died (no autopsy) | + | Pocket of turbid bile in abdomen, *B. coli* (heavy growth); urine, *B. coli* (heavy growth) | Ruptured gall bladder drained, but not removed |
| Died (autopsy) | + | 4+ blood smear, no organisms seen; culture, *Esch. coli* (over 1000 colonies on original plate); peritoneum smear, no organisms; culture proteins, *Esch. coli* and gamma str. fecalis | Chronic cholecystitis and cholelithiasis with an ulcer in wall of gall bladder which had burrowed through the wall, dissecting the layers and finally perforated with leakage of bile down paracolic gutter |
| Well | + | | Cholelithiasis, chronically ulcerated cholecystitis; there is an area of necrosis in the gall bladder wall 2.5 cm. below fundus; in the center of the necrotic area is a perforation |
| *(Patients Not Operated Upon)* | | | |
| Died (autopsy) | + | | Typhoid fever with hyperplasia and ulceration of Peyer's patches; hyperplasia of mesenteric lymph nodes; cholelithiasis and cholecystitis with perforation of the gall bladder and generalized peritonitis; no intestinal perforation |

*(Table II continued on following pages.)*

TABLE II —CON

| NO. | TYPE OF PERFORATION | AGE, RACE, AND SEX | PREOPERATIVE DIAGNOSIS | OPERATION | |
|---|---|---|---|---|---|
| 11 | Free performation at first confined to lesser peritoneal sac and then generalized peritonitis | ? | Died Oct. 11, 1898, and autopsy done by Dr. Flexner; paralytic ileus | No operation (?) | Died |
| 12 | Generalized bile and purulent peritonitis and also large pericholecystic abscess | 70, W., M. | 1. Carcinoma of colon with metastases to liver and lungs<br>2. Carcinoma of stomach | No operation | Died |
| 13 | Generalized purulent peritonitis | 79, W., F., | Acute cholecystitis and cholelithiasis; generalized peritonitis; paralytic ileus | Refused operation | Died |

(Case 7) died the day after cholecystostomy. Prior to death there was a temperature of 105° F. associated with marked respiratory distress. No autopsy was obtained. Two deaths were due to the lack of a correct diagnosis.

The first of these patients (Case 8) was found at operation to have an inflammatory mass producing complete obstruction in the region of the cecum. An ileostomy was performed. The patient died and at autopsy was found to have a perforated gall bladder. Gall bladder contents had escaped down the paracolic gutter to produce the inflammatory paracecal mass. Our interest in this case resulted in this study of perforated gall bladders to determine the incidence and mechanism of associated intestinal obstructions.

The second patient (Case 6) had an exploratory laparotomy for an acute abdominal condition associated with partial intestinal obstruction. A right inguinal abscess was drained. Autopsy revealed a perforated gall bladder which had given rise to the abscesses and intestinal obstructions in each of these cases.

In the group of four cases in which operation had not been done and in which the perforation was discovered at autopsy, two of the deaths (Cases 10 and 11) were in patients (in 1898 and 1901) whose clinical records are not available. One was associated with typhoid fever; neither was operated upon. One death (Case 12) was attributable to the fact that the patient entered the hospital highly jaundiced and moribund. The clinical impression was that the patient had carcinoma of the colon with metastases to the liver and lungs. The second most likely possibility was considered to be a carcinoma of the stomach. Autopsy revealed a carcinoma of the common bile duct at the ampulla of Vater producing partial high intestinal obstruction and chronic cholecystitis with abscess formation in the anterior wall of the gall bladder. The gall bladder had per-

—CONT'D

| RESULT | STONES | BACTERIOLOGY | PATHOLOGY |
|---|---|---|---|
| Died (autopsy) | + | Peritoneal cavity, abscess, liver; Friedländer bacillus | Greatly thickened and inflamed gall bladder full of pus as were all its dilated ducts; it had perforated into an abscess cavity posteriorly (caused by perforation). One stone in gall bladder and two in abscess in lesser omentum. Perforation of abscess with generalized peritonitis and paralytic ileus; viscera covered with fibrinous adhesions |
| Died (autopsy) | | Heart blood, *Esch. coli;* peritoneal fluid, *Esch. communior,* 50 col. and pneumococcus, type 7, 25 col. | Carcinoma of common duct of ampulla of Vater with marked dilatation of pancreatic and bile ducts, jaundice, chronic cholecystitis and abscess formation in anterior wall of gall bladder with perforation, bile peritonitis, biliary cirrhosis and cholecystitis and abscess formation in liver; perforation was not through tumor but away from it |
| Died (autopsy) | + | | Cholelithiasis with impaction of one stone in common duct near papilla, obstruction and dilatation of common duct, jaundice, ulcerative cholecystitis with perforation of wall, local and generalized fibrinopurulent peritonitis |

forated into the peritoneal cavity with resultant peritonitis. The site of the perforation was not near the tumor. There was associated cholangitis and biliary cirrhosis. The fourth patient in this group (Case 13), although having an essentially correct diagnosis, refused operation.

The mortality percentage of 55 in the nine patients operated upon is slightly higher than the average and is considerably higher than such figures as those of Niemeier (0 per cent), Stone and Douglas (0 per cent), Hotz (35.9 per cent), and Cowley and Harkins (16.6 per cent). It should be pointed out that our series includes patients treated almost fifty years ago. Four additional deaths were in patients upon whom no operation was performed. Failure to recognize the correct pathologic process underlying the picture of intestinal obstruction was responsible for two of the deaths.

*Mortality From Localized Perforations of the Gall Bladder.*—In the group of twelve Niemeier type II perforations (with localized pericholecystic abscess) treated by operation, there were no deaths (0 per cent mortality) as shown in Tables IV and V. Three other nonoperated cases were found at autopsy. In

TABLE III. NIEMEIER TYPE I (ACUTE FREE) PERFORATIONS: SUMMARY

| | |
|---|---|
| Surgical patients recovered | 4 |
| Surgical patients died | 5 |
| Total surgical cases (55 per cent mortality) | 9 |
| Autopsy cases (patients not operated upon) | 4 |
| Total cases | 13 |
| Cases with intestinal obstruction* | 5 |

*Thirty-eight per cent with intestinal obstruction.

TABLE IV. NIEMEIER TYPE II

| NUMBER | TYPE OF PERFORATION | AGE, RACE, AND SEX | PREOPERATIVE DIAGNOSIS | OPERATION | |
|---|---|---|---|---|---|
| | | | | | *Surgical* |
| 14 | Localized abscess | 20, W., M. | Rupture of gall bladder | Cholecystostomy | Well |
| 15 | Localized abscess | 57, N., F. | Subsiding atttack of acute cholecystitis superimposed on cholelithiasis | Cholecystostomy | Well |
| 16 | Localized abscess with collection of pus above dome of liver | 70, W., M. | Acute abdominal emergency, etiology unknown | Exploratory laparotomy; cholecystectomy and drainage | Well |
| 17 | Localized abscess (bile and pus) between stomach and diaphragm | 50, W. M. | Acute abdominal emergency<br>1. Acute cholecystitis<br>2. Acute pancreatitis<br>3. Perforated ulcer; peritonitis | Exploratory laparotomy and drainage of abscess | Well |
| 18 | Localized abscess | 56, N., F. | Acute exacerbation of chronic cholecystitis with cholelithiasis | Cholecystectomy | Well |
| 19 | Localized abscess | 61, W., F. | Acute cholecystitis with cholelithiasis, possibly empyema of gall bladder | Cholecystectomy | Well |
| 20 | Localized abscess | 60, W., F. | Chronic cholecystitis and cholelithiasis | Exploration, cholecystectomy, appendectomy | Well |
| 21 | Localized abscess | 35, W. F. | Acute cholecystitis and empyema of gall bladder | Cholecystostomy | Well |
| 22 | Localized abscess (extraperitoneal cavity), stones | 52, N., M. | Common duct stone and ascending cholangitis | Cholecystectomy | Well |

PERFORATIONS (PERICHOLECYSTIC ABSCESS)

| RESULT | STONES | BACTERIOLOGY | PATHOLOGY |
|---|---|---|---|
| *Cases* | | | |
| Well | + ("Mud") | | Ruptured gall bladder drained but not removed; at operation a gangrenous area with a hole ½ cm. long was found; there was a localized abscess containing 10 c.c. of pus about perforation |
| Well | + | *B. coli* (heavy growth) | Empyema of gall bladder, rupture with formation of a localized abscess covered by omentum; ruptured gall bladder drained but not removed |
| Well | + | Gall bladder, *Esch. coli;* abdominal cavity, *Esch. coli* (about liver) | Gall bladder wall thick and hemorrhagic, mucosa ulcerated and covered with a fibrinopurulent exudate; the wall was infiltrated with P.M.N.s and was scarred; there were areas of necrosis. Final diagnosis: cholelithiasis, acute ulcerative cholecystitis with perforation |
| Well | None found | Abscess, *B. coli* (heavy growth) | Ruptured gall bladder drained but not removed; about a quart of bile-stained fluid between stomach and diaphragm (walled off by omentum), gall bladder thickened and grayish white in color, perforation in lower portion near junction with cystic duct |
| Well | + | Culture of abscess, no growth | Gall bladder contained large stone 3 cm. in diameter and was acutely inflamed; its fundus was necrotic and had perforated into an abscess cavity between gall bladder and anterior abdominal wall; abscess well localized by adhesions and contained 20 c.c. of bile-stained fluid |
| Well | + | Gall bladder, *B. coli* (heavy growth) | Omentum plastered to gall bladder and between them a pocket of pus; acute gangrenous cholecystitis with perforation at ampulla; empyema of gall bladder, cholelithiasis |
| Well | + | Culture of abscess, sterile; readmitted 2 mo. later with severe intestinal obstruction due to adhesions; relieved completely with gastric suction | Thickened gall bladder wall with necrosis of mucosa, hemorrhage, P.M.N.s and giant cells in wall, subsequent organization; chronic cholecystitis and cholelithiasis with perforation about one-third way from neck to fundus between gall bladder and liver; pocket of pus under the liver, empyema of gall bladder |
| Well | + | Culture of abscess, *B. coli* | Ruptured gall bladder drained but not removed; it was entirely encapsulated by omentum. Between the two was a considerable amount of bile-stained pus. Gall bladder collapsed and it communicated with abscess via perforation. It contained pus and small stones, cholecystectomy on a later admission; specimen showed chronic cholecystitis |
| Well | + | Extrabiliary stones causing pressure on common duct | Gall bladder had ruptured at ampulla, extraperitoneally, discharging stones, one of the stones impinging on common duct and responsible for jaundice; no stone in common duct but stones in cystic duct; gall bladder tense and showed marked chronic ulcerative cholecystitis |

*(Table IV continued on following pages.)*

TABLE IV

| NUMBER | TYPE OF PERFORATION | AGE, RACE, AND SEX | PREOPERATIVE DIAGNOSIS | OPERATION |
|---|---|---|---|---|
| 23 | Type II. Localized abscess containing bile (almost type I if appendicitis a direct result)? | 41, N., M. | Acute cholecystitis with perforation and generalized peritonitis, appendectomy, postoperative obstruction and mass in gall bladder region; acute cholecystitis | Cholecystectomy and drainage |
| 24 | Localized pericholecystic abscess | 59, N., M. | Carcinoma of stomach | Exploratory laparotomy; cholecystostomy with drainage |
| 25 | Localized abscess | 54, N., F. | Acute cholecystitis and cholelithiasis; no mention of rupture | Cholecystectomy |
| | | | | *Autopsy Cases* |
| 26 | Localized abscess with localized fibrinoperitoneal peritonitis | 65, N., F. | Carcinoma of gall bladder? Infected hydronephrosis; heart failure, renal insufficiency, cardiovascular accident | No operation |
| 27 | Localized pericholecystic abscess, old, containing gallstones | 48, N., F. | Cardiovascular renal disease with hypertension; myocardial insufficiency; terminal pneumonia | No operation |
| 28 | Localized pericholecystic abscess | 68, W., M. | Benign prostatic hypertrophy; chronic pyelonephritis, and renal insufficiency | No operation |

the group of eight Niemeier type III perforations (with internal biliary fistula) treated by operation, there were three deaths (38 per cent mortality). Five other nonoperated cases were found at necropsy. Thus, of the total of twenty surgical cases with localized perforations of the gall bladder, there were three operative deaths; a mortality of 15 per cent, which is about the same as the average in the collected series shown in Table I.

*Incidence of Gallstones as Etiology of Intestinal Obstruction.*—The five cases of intestinal obstruction due to gallstones in this series give an incidence of 12 per cent of all the gall bladder perforations and an incidence of 38 per cent of all the spontaneous internal biliary fistulas. It is probable that with the ad-

—CONT'D

| RESULT | STONES | BACTERIOLOGY | PATHOLOGY |
|---|---|---|---|
| Well | Mass of inspissated bile | Gall bladder, heavy growth of *B. coli* | Gall bladder about completely gangrenous and surrounded by a pocket of bile walled off by stomach, colon, and liver; it was tense and contained 40 c.c. of thick, dark, fecal-smelling bile. Most of the mucosa had disappeared and necrosis extended all the way through the wall which was heavily infiltrated with P.M.N.s and round cells |
| Well | Piece of black putty-like material | Abscess, *Esch. communior* | Fresh fibrinous peritoneal adhesions walled off an abscess about gall bladder, containing 400 c.c. of bile-stained pus; abscess communicated with lumen of gall bladder through necrotic perforation in fundus about 2 cm. in diameter; ruptured gall bladder drained, but not removed |
| Well | + | Abscess, gamma str. fecalis | Gall bladder found covered by stomach and between the two was an abscess containing 3 c.c. of thick yellow pus; abscess communicated with a perforation in gall bladder. Final diagnosis: Cholelithiasis, ulcerative cholecystitis with perforation |
| *(Patients Not Operated Upon)* | | | |
| Died (autopsy) | + | Abscess, ***Esch. coli*** (1000 col. on original plate) and *Cl. welchii;* blood culture, *Esch. coli* and *B. subtilis* | Chronic cholecystitis, cholelithiasis, stone in ampulla of Vater, dilatation of bile ducts, acute hepatitis, empyema of gall bladder, adhesions to colon, stomach, duodenum; rupture of cystic duct and abscess about right lobe of liver; localized fibrinopurulent peritonitis, nephritis |
| Died (autopsy) | + | | An incidental finding at autopsy was cholecystitis and cholelithiasis with several large gallstones outside of gall bladder between gall bladder and liver, partly eroding liver; perforation was sealed over and the extrabiliary stones were well walled off |
| Died (autopsy) | None mentioned | | Ulcerative diphtheritic cholecystitis with perforation, abscess in wall of gall bladder and liver, gall bladder distended with bile; mucosa contains many yellow ringed necrotic ulcers, one of which has perforated, forming an abscess under the neck of the gall bladder above the superior part of the duodenum; carcinoma of prostate, cystitis, pyelonephritis, pneumonia |

vent of modern surgical methods the frequency of this condition has diminished. There have been numerous reports of isolated cases since Bartholin reported the first case in 1654. Courvoisier collected 131 instances of the syndrome in 1890 and Moore (1925) estimated that about 400 cases had accumulated in the literature by 1925. Fitz (1888) rated the incidence of obstructions due to gallstones as high as 7.7 per cent and Leichtenstern (1876) rated it as 3.6 per cent of all intestinal obstructions (in series of collected cases) in the early literature, but subsequent reports have put the figure between 0.36 and 2.2 per cent.

*Mortality Associated With Internal Biliary Fistulas.*—As already stated, of the eight patients treated by operation, three died, a mortality of 38 per cent.

TABLE V. NIEMEIER TYPE II (SUBACUTE PERICHOLECYSTIC ABSCESS) PERFORATIONS: SUMMARY

| | |
|---|---|
| Surgical patients recovered | 12 |
| Surgical patients died | 0 |
| Total surgical cases (0 per cent mortality) | 12 |
| Autopsy cases (patients not operated upon) | 3 |
| Total cases | 15 |
| Cases with intestinal obstruction* | 1 |

*Seven per cent with intestinal obstruction.

Eight of the entire group of thirteen internal fistulas were unassociated with gallstone obstruction as shown in Tables VI and VII. Two of these fistulas contained large gallstones which had not entered the intestinal tract sufficiently to produce obstruction. In one case the fistula was due to a carcinoma of the gall bladder from which the patient died. Two others also had carcinomas of the gall bladder and cholelithiasis. In these it appeared that the perforations into the intestinal tract were not due to the coexisting carcinomas but to the pressure necrosis and erosion produced by the stones. Of the eight cases unassociated with gallstone obstruction, six patients died (five without operation). Three of these deaths were due to carcinoma of the gall bladder. Two of the fistulas were incidental findings at autopsy in patients dying of tuberculous meningitis and septicemia, respectively. It is interesting that the remaining death was in the first patient ever autopsied at this hospital. He was a 68-year-old white man who was admitted to Dr. Osler's service in 1889. He was intensely jaundiced, obstinately constipated, emaciated, and moribund on admission. Autopsy revealed chronic cholecystitis and cholelithiasis, a common duct-duodenal fistula and biliary cirrhosis (only the gross report available). There were two other fistulas not included in this study. One was due to tuberculous ulceration of the duodenum and the other was not a true fistula but functioned as such. This case was one in which there was marked dilatation of the common bile duct associated with a congenital stenosis of the duodenum. A case of fistula due to erosion of the gall bladder by a duodenal ulcer was also encountered but has not been included in this report.

*Mortality From Gallstone Ileus.*—Of 153 patients with internal biliary fistula seen at the Mayo Clinic and reported by Judd and Burden (1925) only one had obstruction of the intestine by a gallstone. In institutions such as the Johns Hopkins Hospital located in a large community, however, this low incidence of associated obstruction is not to be found. The factor of gallstone obstruction was present in over one-third of the fistulas seen and in over one-half of the fistulas coming to operation (five out of eight cases). Two of the five patients with gallstone ileus died (a mortality of 40 per cent). One died while on the operating table as the primary incision was being made. This death was justifiably attributed to spinal anesthesia. No autopsy was obtained. The second patient died on the second postoperative day following an exploratory laparotomy for what was believed to be "carcinoma of the gall bladder with

pressure on the duodenum causing high intestinal obstruction." A carcinoma of the gall bladder which was invading the liver was found at operation along with cholecystitis and cholelithiasis with a cholecystileal fistula. The fistula was not directly associated with the carcinoma. Autopsy revealed that the immediate cause of death was complete intestinal obstruction due to a large gallstone which had lodged in the terminal ileum.

Our mortality rate of 40 per cent for gallstone ileus is similar to that cited by other authors (50 to 80 per cent as reported by Martin, 1912; Powers, 1928; Vick, 1932; Vidgoff, 1933; Borman and Rigler, 1937; Balch, 1938; and in a discussion in the *Proceedings of the Section on Surgery of the British Medical Association* in 1925). On the other hand, the mortality of intestinal obstruction due to all causes was reported as 26.6 per cent by Vick (1932). Since the advent of duodenal suction and Miller-Abbott tube drainage, this mortality due to all types of obstruction has diminished to from 15 (Leigh, Nelson, and Swenson, 1940, and Dennis and Brown, 1942) to 22 per cent or less (Lewis, Shapiro, and Vaughan, 1940, and Schlicke, Bargen, and Dixon, 1940). Johnston (1940) reported a mortality of 19.1 per cent in sixty-three patients at the Detroit Receiving Hospital with nonstrangulated obstructions.

The high mortality from gallstone ileus is not to be accepted as inevitable and the important contribution of Rigler, Borman, and Noble (1941) on the roentgen diagnosis of internal biliary fistula and gallstone ileus should aid materially in reducing it. Finney (1942) in discussing three cases of gallstone ileus reported at the Women's Hospital in Baltimore mentions an instance in which a flat plate of the abdomen revealed the common duct and the hepatic duct outlined with air and also a suspicious shadow in the ileum. A diagnosis of gallstone ileus was made and the gallstone was removed. Two days later the patient again developed signs of obstruction and a second flat plate showed another gallstone in the lower ileum. A second operation was performed, and the gallstone was removed. That patient lived, but one of the other two patients died (a mortality of 33.3 per cent in the three cases, which Finney considered high). It is well known that the relatively high mortality due to gallstone obstruction is accounted for in part by the advanced age of the majority of patients and in part by the atypical clinical picture which makes a correct diagnosis difficult. The various features of this unusual but highly dangerous type of intestinal obstruction have been dealt with in great detail by others and it is not the purpose of this report to repeat them. It is always worth while to reiterate, however, that to be diagnosed the condition has to be thought of, especially when a surgeon is confronted with a case of intestinal obstruction in a patient over 50 years of age with a history of right upper quadrant pain or other symptoms referable to the gall bladder in whom no other cause for the obstruction is evident.

Although all five cases of gallstone obstruction had what would be classed as simple nonstrangulated obstruction, it is known that gallstones in the intestinal tract may be associated with volvulus (closed loop) above the site of the obstruction (Robson, 1904; Smith, 1925), with strangulation of the bowel by overdistention (Storck, 1939), or with perforation leading to peritonitis (Balch,

TABLE VI. NIEMEIER TYPE III

| NUMBER | TYPE OF PERFORATION | AGE, RACE, AND SEX | PREOPERATIVE DIAGNOSIS | OPERATION |
|---|---|---|---|---|
| | | | | *Surgical* |
| 29 | Fistula into duodenum | 64, W., M. | Pernicious anemia in remission; cholelithiasis with stone in common duct | Exploratory laparotomy |
| 30 | Fistula into colon | 59, W., M. | Chronic cholecystitis and cholelithiasis | Exploratory laparotomy; release of adhesions between colon and small intestine, cholecystectomy, exploration of common duct |
| 31 | Fistula of gall bladder into ileum associated with carcinoma of gall bladder and gallstone ileus (carcinoma at one end of gall bladder; fistula at other) | 63, W., F. | 1. Carcinoma of gall bladder with pressure on duodenum causing high intestinal obstruction<br>2. Hydrops of gall bladder; carcinoma of stomach with metastases to liver | Exploratory laparotomy |
| 32 | Fistula into stomach with gallstone ileus (1945) | 49, W., F. | 1. Paralytic ileus with cholelithiasis<br>2. High intestinal obstruction and possible gall bladder disease | Exploratory laparotomy; removal of gallstone from terminal ileum |
| 33 | Fistula into small intestine | 78, W., F. | Episode of high intestinal obstruction "mesenteric in type." Medical consultant: No obstruction at present, carcinoma with partial obstruction? Colitis? Diverticula? No operation indicated at present | Exploratory laparotomy; large stone found in terminal ileum with complete obstruction |
| 34 | Common duct-duodenal fistula | 50, N., F. | Cholecystitis with cholelithiasis | Cholecystectomy with drainage of empyema |
| 35 | Perforation into small intestine with gallstone ileus | 59, W., M. | 1. Carcinoma of prostate<br>2. Obstruction high in G.I. tract, probably stomach<br>3. Carcinoma of stomach | Exploratory laparotomy; removal of gallstone from jejunum with relief of obstruction |
| 36 | Cholecystenteric fistula? | 69, N., F. | Intestinal obstruction near ileocecal valve | Exploratory laparotomy; removal of gallstone from terminal ileum; gallstone 3 cm. in diameter was producing complete obstruction |

PERFORATIONS (INTERNAL BILIARY FISTULA)

| RESULT | STONES | BACTERIOLOGY | PATHOLOGY |
|---|---|---|---|
| *Cases* | | | |
| Well | None seen; no history of ever passing any | | Many adhesions about gall bladder, large fistula between gall bladder and duodenum 1 cm. thick and 2 cm. long; gall bladder small and thick walled, no stones |
| Well | + (Not yet extended into G.I. tract) | | Many adhesions between gall bladder and colon and small intestine and colon; fistula between gall bladder and colon through which a stone had eroded, still adherent to the fistula; numerous stones had also eroded gall bladder wall and one had about perforated into the peritoneal cavity. Final diagnosis: Chronic cholecystitis and cholelithiasis with perforation into colon |
| Died (autopsy) | + | (Stone in ileum missed at operation) | Cholelithiasis and chronic cholecystitis, fistula between gall bladder and ileum, large gallstone obstructing ileum; adenocarcinoma (at other end of gall bladder) of gall bladder with extension of tumor into liver; although partial obstruction of duodenum relieved at operation, gallstone in ileum producing complete obstruction was missed |
| Well | + | | Large gallstone in ileum producing complete intestinal obstruction; fistula not visualized |
| Died on table under spinal anesthesia (no autopsy) | + | | Large gallstone removed from ileum, which was producing complete intestinal obstruction; gall bladder palpated and found to be bound down by adhesions and full of stones; fistula not seen; no autopsy |
| Died on 8th P.O. day with temperature of 103° F. (autopsy) | + | (Stone had almost perforated into duodenum) | Common duct very dilated, measuring 2.5 cm. in circumference, thick walled and has a bright yellow mucosa; contains a dark brown gallstone 1 cm. in diameter about 5 cm. from its normal opening into duodenum. Just above this the mucosa of the duodenum is elevated and darkened over the stone; in the center of this area is a perforation through which stone can be seen and through which gallstone was about to perforate into duodenum; no peritonitis |
| Improved (died the next year of carcinoma of prostate) | + | | Cholelithiasis; cholecystitis, chronic; perforation of gall bladder with fistula to small intestine; intestinal obstruction due to gallstone 2 cm. in diameter; carcinoma of prostate |
| Well | + | | No fistula was palpated; the surgeon believed there was a dilated common duct through which stone had passed, but did not visualize the gall bladder region |

*(Table VI continued on following pages.)*

TABLE VI

| NUMBER | TYPE OF PERFORATION | AGE, RACE, AND SEX | PREOPERATIVE DIAGNOSIS | OPERATION | |
|---|---|---|---|---|---|
| | | | | | *Autopsy Cases* |
| 37 | Perforation into a viscus due to carcinoma of gall bladder (perforation into colon) | 69, W., M. | Carcinoma of liver | No operation | Died |
| 38 | Cholecystocolic fistula | 66, Chinese, M. | Autopsy record: Extensive str. infection of genitals and surrounding structures; septicemia, diabetes | No gall bladder operation; G.U. service | Died |
| 39 | Common duct-duodenal fistula | 68, W., M. | Intense jaundice, obstinate constipation, emaciation, Dr. Osler's service 1889, moribund | No operation; medical service | Died |
| 40 | Cholecystoduodenal fistula | 43, W., M. | Tuberculous meningitis | No opration; medical service | Died |
| 41 | Perforation into duodenum due to carcinoma of gall bladder | 69, W., M. | 1. Pulmonary tuberculosis with tuberculous glands pressing on duodenum, causing intestinal obstruction<br>2. Carcinoma of G.I. tract with metastases to liver | No operation | Died |

1938; Storck, 1939). There is often a necrotizing enteritis at the site of lodgment of the stone and an impaired blood supply to this region. The possible development of these types of bowel damage is of interest in view of the recent demonstration of the protective effect of penicillin in closed isolated jejunal loops in dogs (Harper and Blain, 1945) and in strangulated low ileal obstructions in dogs (Blain and Kennedy, 1946).

*Report of Cases.*—All forty-one cases in this series have been grouped according to Niemeier's three types of perforation of the gall bladder. The age, sex, race, preoperative diagnosis, operation, and result for each patient are indicated in Tables II, III, and IV. In addition the presence or absence of gallstones has been noted and the pathologic diagnosis (autopsy or surgical pathologic report) summarized. Cowley and Harkins (1943) and many others have studied the symptoms and other features of gall bladder perforations. Inasmuch as this study has been concerned primarily with the cases in which gall bladder perforations have been responsible for intestinal obstruction only those patients who developed intestinal obstruction will be discussed in any detail.

## CASE REPORTS

*Intestinal Obstructions Associated With Type I (Niemeier) Perforations of the Gall Bladder.*—Five (45 per cent) of the cases in this study in which in-

—CONT'D

| RESULT | STONES | BACTERIOLOGY | PATHOLOGY |
|---|---|---|---|
| *(Patients Not Operated Upon)* | | | |
| Died (autopsy) | | | Carcinoma of gall bladder with extensive involvement of liver; metastases to lungs, spleen, and kidneys. Cholecystocolonic fistula; peritoneal adhesions, ascites, bilateral hydrothorax; fistula due to carcinoma of gall bladder |
| Died (autopsy) | + | | Cholelithiasis with obstruction of cystic duct and cholecystocolonic fistula; chronic cholecystitis, early biliary cirrhosis of liver, extensive infection of perineum |
| Died (autopsy) | + (None in intestinal tract) | (First autopsy performed at J.H.H.) | Common duct very dilated and connected to lumen of duodenum by a fistula (round ulcerated opening 3 cm. in diameter); common duct full of stones; normal opening of common duct into duodenum not dilated. Gall bladder contracted about stones; stones in other duct, no stones in intestine, no microscopic report |
| Died (autopsy) | None found | | Incidental finding at autopsy was fistula between gall bladder and duodenum, gall bladder very shrunken, cystic and common ducts bile-stained, and not dilated; ampulla of Vater patent, no stones, tuberculous meningitis |
| Died (autopsy) | + | Gall bladder, gamma str. and *B. coli* | Adeno- and colloid carcinoma of gall bladder with metastases to liver, regional lymph nodes, and omentum. Cholelithiasis; fistula between gall bladder and duodenum; multiple abscesses in tumor and liver. Stone in common duct near ampulla; dilated bile ducts; jaundice; biliary cirrhosis; pulmonary tuberculosis |

testinal obstruction was an important factor may be classed as involving free perforations. Two of these resulted in multiple abdominal abscess formation rather than an out-and-out generalized peritonitis. In neither case was the etiology of the abscess formation diagnosed and both patients died. Bile peritonitis (Harkins, Harmon, and Hudson, 1936) may exist concomitantly with intestinal obstruction in these cases and the two conditions act conjointly to increase the seriousness of each other and to raise the resultant mortality. Of the group of five patients who developed intestinal obstruction, the first three

TABLE VII. NIEMEIER TYPE II (CHRONIC INTERNAL BILIARY FISTULA) PERFORATIONS: SUMMARY

| | |
|---|---|
| Surgical patients recovered | 5 |
| Surgical patients died | 3 |
| Total surgical cases (38 per cent mortality) | 8 |
| Autopsy cases (patients not operated upon) | 5 |
| Total cases | 13 |
| Cases with intestinal obstruction* (5 cases of gallstone ileus) (0 cases of inflammatory or paralytic ileus) | 5 |

*Thirty-eight per cent with intestinal obstruction.

were operated upon with two deaths (67 per cent mortality) and the other two obstructions were discovered at autopsy in patients who had had no operation.

CASE 4.—A 46-year-old white man had had difficulty since boyhood with epigastric fullness and nausea after eating. He was admitted to the gastrointestinal clinic because of right upper quadrant pain. A gall bladder series was done but was unsatisfactory. While it was being repeated he was suddenly seized with a severe pain in the abdomen, not too well localized but apparently more intense in the region above the umbilicus. He was cold and clammy when brought to the accident room. The pulse was rapid and he was in severe agony. Temperature was 101.6° F., pulse, 112. The blood pressure was 140/85 and the respirations were 24. He was obese and not jaundiced. There was marked spasm and a rebound tenderness in the right upper quadrant. There was exquisite tenderness on pressure in this region. The boyhood symptoms had been more severe for the past five years, especially after ingestion of fried or fatty foods. At such times there was eructation, a feeling of epigastric fullness, a bad taste in the mouth, and heartburn. In the past five days the symptoms had been more severe than ever before and were associated with vomiting and constipation. The preoperative diagnosis was that he had an acute exacerbation of a chronic cholecystitis with cholelithiasis, and that there was an associated paralytic ileus. Because the patient was very obese and the gall bladder inaccessible and very friable at operation drainage of the gall bladder region was all that was carried out. A large hole was seen in the gall bladder fundus. This was now partially plugged with omentum. There were several large gallstones free in the peritoneal cavity which also contained a fair amount of bile-stained fluid. This peritoneal fluid was cultured on blood agar and on broth without any growth. The patient was improved as a result of the operation but returned one year later with a history of symptoms referable to the gall bladder of three weeks' duration. He was given admission slips but refused further operation and has not been heard from since.

CASE 6.—A 64-year-old white man entered the hospital with symptoms of an acute abdominal condition, the onset of which had occurred ten days prior to admission. There had been partial intestinal obstruction and pain which was localized chiefly to the epigastrium. At the exploratory laparotomy done soon after admission a large abscess was found in the anterior part of the right lumbar region and the abdominal cavity contained a large amount of blood. The appendix was not found at operation and the cause of the abscess remained unknown. Inasmuch as this operation was performed before the advent of the Wangensteen and Miller-Abbott tubes, a loop of bowel was brought into the abdominal incision. During the next twenty-four hours there was no bowel movement. An enterostomy was done on the exposed loop, but the patient died two weeks after operation. Postoperatively the temperature had always been subnormal and there had been a leukocytosis ranging around 10,000. Culture of the abscess at operation showed *Bacillus coli*.

Autopsy revealed a gangrenous gall bladder which had perforated in two places. These perforations communicated with a large abscess in the right lumbar region. There were many other abscesses in the region of the cecum and in the pelvis. The intestines were greatly kinked and bound together producing the obstruction. There were no gallstones. The final diagnosis was gangrenous cholecystitis; rupture of the gall bladder with formation of a large abscess in the right lumbar region and many small abscesses in the ileocecal region and pelvis; chronic widespread adhesive peritonitis; operation wound (drainage of abscess and enterostomy); and acute catarrhal enteritis.

CASE 8.—A 47-year-old white man entered the hospital with a chief complaint of abdominal pain of ten days' duration. The history, which was judged to be rather unreliable, was as follows. There had been anorexia for two years but digestion had been normal. There had been very vague right upper quadrant pains several years before. There was no eructation, nausea, or vomiting. Seven months before admission the patient had experienced pain in the epigastrium which lasted three or four days. This pain was unrelated to eating and was not associated with nausea or vomiting. Bowel habits had been regular until the onset of the present illness. There had been no clay-colored or tarry stools and there was no jaun-

dice. Ten days prior to admission he had a pain in the epigastrium. This pain was at first dull and intermittent but after the ingestion of a laxative became severe and colicky in character. There were many bowel movements but no nausea or vomiting. The pain persisted in the epigastrium until three days prior to admission, when it became localized in the right lower quadrant. There was associated generalized abdominal tenderness and soreness. At this time the attacks of colic became so severe that he doubled up in pain and there was nausea and vomiting. The vomitus was green and bitter. He was admitted to another hospital and then transferred to this hospital. On admission the temperature was 100° F., pulse was 90, respirations were 38, blood pressure was 135/70, and white blood cell count was 7,800. He appeared acutely and chronically ill. The abdomen was distended and there was generalized tenderness and muscle spasm which was most marked in the right lower quadrant. There was also a palpable, exquisitely tender mass in the right lower quadrant. The abdomen although tympanitic to percussion was dull in this area. The abdomen was silent to auscultation with occasional series of metallic tinklings. A Miller-Abbott tube was introduced and intravenous fluid therapy was begun. The following day the distention and pain were more marked. On the basis of the clinical and x-ray findings a diagnosis of acute complete intestinal obstruction due to an inflammatory or neoplastic cecal mass was made. On the third hospital day an exploratory laparotomy was performed. A mass which was judged to be of neoplastic origin was found in the region of the cecum. A terminal ileostomy was done. The patient died on the second postoperative day with a fever of 102° F. An autopsy revealed a chronic cholecystitis and cholelithiasis. There was an ulcer in the mucosa of the gall bladder which had burrowed through the wall dissecting the layers. This had finally perforated and through the perforation bile had leaked down the paracolic gutter to produce an inflammatory mass. The mass was the cause of a complete intestinal obstruction. A smear made from the peritoneum in the region of the mass showed no organisms but a culture grew *Bacillus proteus, Escherichia coli,* and an alpha *Streptococcus fecalis.*

It is significant that at the clinical pathologic conference at which this case was presented the correct diagnosis was no more suspected by the participants than it had been while the patient was alive.

The other three cases in which free (Niemeier type I) perforations resulted in intestinal obstructions were essentially cases of generalized peritonitis with resultant paralytic ileus. In two of these the correct diagnosis was made preoperatively although in one it is not clear that generalized peritonitis was suspected. The third patient was treated so long ago that only the autopsy record is available.

CASE 11.—This case is from the early autopsy records and is one in which a greatly thickened and inflamed gall bladder was found to be full of purulent exudate. It had perforated posteriorly forming a large abscess cavity. There was a stone in the gall bladder and there were two stones in the abscess cavity. There was a generalized peritonitis associated with paralytic ileus. The viscera such as the stomach and liver were covered with fibrinous adhesions. It is of interest that cultures of the abscess cavity, the surfaces of the spleen and liver, and the peritoneal fluid all yielded pure growths of the Bacillus of Friedländer.

CASE 13.—A 79-year-old woman who was jaundiced, deaf, filthy, and undernourished was brought to the hospital by the police. They had found her living alone in utter squalor. The history was hard to obtain and was not reliable. She had supposedly lived for years on doughnuts and sausages. She had been constipated for a long time. She had been growing progressively weaker for two years with intermittent jaundice, and on admission could not stand unaided. For the past few days prior to admission she had had incontinence of urine. Jaundice had increased markedly during the three days before admission and at the time of admission she complained of abdominal pain and drowsiness. On admission the white blood cell count was 44,800 (94.5 per cent polymorphonuclear leucocytes), temperature 97.4° F., pulse 100, respirations were 20, and the blood pressure was 140/62. Physical exam-

ination revealed a filthy, drowsy, uncooperative, jaundiced, malnourished, weak old woman in no apparent pain. There was moderate abdominal distention and there was some tenderness on pressure over the whole upper abdomen. This was perhaps more marked in the epigastrium and under the right costal margin. There was no muscle spasm and no masses were palpated. The clinical impression was given as "dehydration, probably with acidosis; senility and arteriosclerosis, icterus (with many scratch marks) due probably to gallstones." The leucocytosis suggested probable empyema of the gall bladder following cholelithiasis. She refused an operation and died six weeks later of heart failure. During the first three weeks in the hospital temperature ranged around 102 to 103° F. In the fourth week she had severe abdominal pain, marked distention, right upper quadrant pain, spasm, and tenderness. At this time the temperature ranged between 103 and 104° F. and the jaundice began to increase. Auricular fibrillation developed and she died with pulmonary edema. The last few days the abdominal distention was greater and there were no audible peristalses. The abdomen was spastic and there was obstipation and vomiting. The final clinical impression was acute and chronic cholecystitis and cholelithiasis with necrosis of the gall bladder probably causing generalized peritonitis and paralytic ileus. The findings at autopsy were as follows: Cholelithiasis with impaction of one stone in common duct near papilla; obstruction and dilatation of common duct; jaundice; ulcerative cholecystitis with perforation of the gall bladder wall; and local and generalized fibrinopurulent peritonitis. There was also bilateral hydrothorax, pulmonary edema, and other findings referable to the heart disease.

*Intestinal Obstructions Associated With Type II (Niemeier) Perforations of the Gall Bladder.*—Only one of the eleven cases of intestinal obstruction (9 per cent) was associated with a perforation of the gall bladder with localized abscess formation. The patient was operated upon and recovery resulted. This was a complex one in which intestinal obstruction followed an operation for a ruptured appendix. The coexistent distention obscured for a time the fact that an acute empyema of the gall bladder had led to its perforation and the development of a large pericholecystic abscess which was walled off by the stomach, colon, and liver. It is not known whether the appendicitis was the cause of or the result of the cholecystitis. It is also not definitely known whether the obstructive symptoms were the result primarily of the pericholecystic abscess, a paralytic ileus, or both.

CASE 24.—A 41-year-old colored man entered the hospital complaining of abdominal pain of one week's duration. This pain was associated with nausea and vomiting but there had been a normal bowel movement every day of the illness. Although it was most marked in the right lower quadrant it was generalized. On admission the white blood cell count was 19,800, the temperature 99.4° F., pulse 96, respirations were 24, and the blood pressure was 125/80. The abdomen was distended and was diffusely rigid and tender. The diagnosis was acute appendicitis with perforation and peritonitis. An appendectomy with drainage was carried out. Microscopic sections of the appendix showed acute and chronic appendicitis with a large amount of fibrinopurulent exudate on its serosal surface. Postoperatively the patient had abdominal pain and progressively increasing distention in spite of Wangensteen suction, enemas, and other measures. By the fifteenth postoperative day the patient was very ill. The temperature had risen to 102° F. and the white blood cell count was 25,000. On this day a hard area was palpated under the right costal margin. This area was about 4 by 4 cm. in diameter and was exquisitely tender. A diagnosis of acute cholecystitis was made and a cholecystectomy with drainage was carried out. At operation the gall bladder was found to be almost completely gangrenous and it was surrounded by a large pocket of bile which was walled off by the stomach, colon, and liver. Although it had perforated, the gall bladder was now tense, large, and swollen. About 40 c.c. of thick dark bile was aspirated from its lumen. Its surface was injected and somewhat hemorrhagic. The aspirated bile had a fecal

odor. Microscopic study of the gall bladder revealed that only a small portion of the mucosa remained. There was a heavy infiltration of the wall by both polymorphonuclear leucocytes and round cells. Areas of gangrene extended all the way through the wall. Cultures of the gall bladder contents produced a heavy growth of *B. coli*. The postoperative course following this operation was uneventful and the patient was cured.

*Intestinal Obstructions Associated With Type III (Niemeier) Perforations of the Gall Bladder.*—Five cases (45 per cent of the total of eleven cases) of intestinal obstruction associated with all types of gall bladder perforation were seen in connection with biliary-intestinal fistulas. All of these were, in turn, directly due to gallstone ileus. All of the patients were operated upon and two of the five died (a mortality of 40 per cent).

CASE 31.—A 63-year-old white woman came to the medical dispensary complaining of abdominal pain and of having vomited fifteen times during the day. The vomitus was at first green and later was brown and foul smelling. Her family physician had told her fifteen years before that she had gall bladder trouble. She said that she had lost fifty pounds of weight in the past several months. During this time she had suffered from short knife-like abdominal pains occurring in the mornings and not related to meals. She had become increasingly constipated without any essential changes in the character of the stools. They were not bloody or tarry in character. There had been no jaundice. There was a nodular mass in the right upper quadrant which descended to the level of the umbilicus. The clinical impression was that she had either carcinoma of the gall bladder with pressure on the duodenum causing high intestinal obstruction or hydrops of the gall bladder associated with carcinoma of the stomach which had metastasized to the liver. At operation the gall bladder was found to be acutely inflamed and full of stones. At the fundus was a carcinoma which had extended into the liver. At the other end of the gall bladder near the cystic duct the gall bladder had perforated into the ileum. Six black faceted stones and a large amount of pus were evacuated from the organ, a drain was put into it, and the abdomen was closed. Cultures from the gall bladder grew *B. coli*. The patient died on the first postoperative day and at autopsy a large gallstone was found in the ileum producing complete intestinal obstruction. Although the surgeon found partial duodenal obstruction at operation, the complete low ileal obstruction due to the presence of a large gallstone was missed. The final anatomic diagnosis was as follows: cholelithiasis and chronic cholecystitis; fistula between the gall bladder and ileum; large gallstone obstructing the ileum; and adenocarcinoma of the gall bladder with extension of the tumor into the liver.

CASE 32.—A 49-year-old woman was admitted on April 11, 1945, complaining of vomiting and right upper quadrant pain of six days' duration. She had had attacks of vomiting and right upper quadrant pain for twenty-five years or more. There had been an intolerance for fatty and fried foods for many years. There had never been any jaundice. She had been told by a physician that these "bilious attacks" were due to gall bladder disease and he had put her on a low fat diet. She remained well while on this diet but as soon as she deviated from it the symptoms would return. In the past the attacks had come on suddenly and lasted two or three days. They disappeared as suddenly as they had appeared. Six days prior to admission she drank several highballs and ate some pie in the evening. At 3 A.M. she was awakened from sleep with a severe right upper quadrant pain which lasted two hours and left a dull ache in this region. Since then she had vomited everything that she had eaten. On admission she was acutely ill and dehydrated but in no acute pain. Temperature was 100° F., pulse 92, respirations were 32, and blood pressure was 150/88. She was moderately obese; the abdomen was full but soft in the right upper quadrant. There was generalized tenderness without point pain. There were no borborygmi or visible peristaltic waves. A roentgenogram of the abdomen showed dilated loops of small intestine chiefly on the left side, indicating the presence of obstruction. A diagnosis of paralytic ileus with cholelithiasis was made by the surgical staff. A medical consultant made a diagnosis of high intestinal obstruction with

possible gall bladder disease. An exploratory operation was done and the small intestine was found to be considerably dilated while the large bowel was collapsed. Palpation of the terminal ileum revealed a mass 10 cm. proximal to the ileocecal valve. This mass was believed to be a gallstone. It was removed from the ileum and found to be a fairly large gallstone. Palpation of the gall bladder revealed at least one other large stone still contained within it. Because of the condition of the patient it was decided to defer cholecystectomy until a later operation and to watch her carefully in the meantime for a recurrence of gallstone obstruction. On July 6, 1945, after an uneventful recovery and interval, a cholecystectomy and closure of a cholecystogastric fistula were carried out. There was a 5 Gm. stone in the gall bladder and there was a good deal of chronic inflammation in the gall bladder wall. Recovery from the second operation was also uneventful.

CASE 33.—A 78-year-old white woman was admitted because of abdominal cramps, nausea, and vomiting of eight hours' duration. She had been generally well but for the past three weeks had had mild indigestion characterized by a feeling of fullness and considerable eructation after meals. She had had only two previous similar episodes. However, there was no constipation or abdominal pain and the bowel movements were regular. There were no bloody or tarry stools and there was no diarrhea, jaundice, chills, or fever. At eight o'clock the night prior to admission she was seized with sudden cramplike pains in the abdomen, apparently centering about the umbilicus, radiating outward over the abdomen and occasionally to the shoulders. These pains came and went frequently. She then vomited her supper and later bile and a more or less clear fluid. She noticed no abdominal swelling. The pains had subsided at the time of admission. Temperature was 100° F., pulse 90, respirations were 20, and blood pressure was 170/110. She was in no acute distress during the physical examination, which was essentially negative, except for abdominal swelling. There was no abdominal tenderness or masses. It was the impression of the examining physicians that she had had an episode of high intestinal obstruction. The white blood cell count revealed a leucocytosis of 16,000. The hemoglobin was 100 per cent. Soon after admission the pains recurred. A medical consultant felt that there was no serious obstruction at the time and suggested the following possibilities: carcinoma with low-grade intestinal obstruction, colitis, and diverticulitis. The next day she passed a stool containing mucus following an enema. She continued to vomit a small amount. Because of the obscure nature of the illness an exploratory operation was performed. At operation a loop of ileum was brought up into the incision and this loop contained a gallstone the size of a hickory nut lying in the terminal 10 c.c. of ileum. Above this the bowel was dilated and below it was collapsed. The region of the gall bladder was then explored by palpation, but was not actually seen, and this organ was found to be bound down by adhesions, and several other gallstones could be palpated. There were no other stones in the small bowel. At this point in the operation the patient suddenly became cyanotic and pulseless and died. This death was in all probability ascribed rightly to spinal anesthesia. Permission for an autopsy could not be obtained.

CASE 35.—A 59-year-old white man was admitted to the hospital with a history of anorexia, weakness, and weight loss of ten weeks' duration. There was no melena or hematemesis. Twelve days prior to admission he was seized with a severe cramping abdominal pain associated with vomiting. He vomited six times and that night the pain abated. The patient described the vomitus as green at first and later brown with a foul taste and odor. There were no bowel movements after the day of onset. Three days prior to admission he again vomited several times and had transient crampy pains in the lower abdomen. These pains were periodic and were not concomitant with the vomiting spells. On the day of admission there was fecal vomiting. The temperature was 98.6° F., pulse 80, respirations were 20, and the blood pressure was 120/80. He complained that he had been unable to keep any food in the stomach for the past three days and he hiccuped constantly. The hemoglobin was 83 per cent. He was an obviously ill elderly white man who appeared to have lost weight. He was alert and said that he had pain in the epigastric region although there was no definite tenderness or muscle spasm there. There was a slight rigidity in the right upper quadrant. The abdomen was not markedly distended. The liver and spleen were not palpable. On rectal examination

a large stony hard nodule was palpated in the left lobe of the prostate. X-ray studies revealed that the stomach was dilated with a defect at the pylorus and partial obstruction. The roentgenograms suggested "an ulcerative lesion." A preoperative diagnosis of obstruction high in the intestinal tract probably due to carcinoma of the stomach was made. It was also believed that there was carcinoma of the prostate. An exploratory operation was performed and the stomach was found to be normal to palpation and inspection. There were adhesions about the gall bladder attaching it to the duodenum and surrounding a fistula between the gall bladder and duodenum. Several loops of moderately dilated and hypertrophied small intestine were found. On tracing these downward, a large gallstone was found three feet below the duodenojejunal junction. This caused complete obstruction and the bowel distal to it was completely collapsed. After the removal of the gallstone from the jejunum the patient improved. He was discharged, however, with symptoms of urinary tract obstruction. He died at home approximately ten months later, presumably of carcinoma of the prostate. No autopsy was performed. The diagnosis on discharge was cholelithiasis, chronic cholecystitis, perforation of the gall bladder with a fistula to the small intestine, intestinal obstruction due to a gallstone and carcinoma of the prostate.

CASE 36.—A 69-year-old colored woman was admitted with a history of constipation of four days' duration. During the first three of these days she had vomited once daily and on the fourth day (the day of admission) she vomited twice. During the first three days there were associated epigastric and generalized abdominal cramps which had ceased on the day of admission. Examination of the abdomen revealed no distention, tenderness, or masses. Roentgen examination showed fluid levels in dilated loops of bowel suggestive of an obstructive lesion in the small intestine, probably in the region of the ileocecal valve. Past history was interesting in that there had never been any symptoms referable to the gastrointestinal tract other than a mild chronic constipation. Appetite had always been excellent. On admission, enemas were ineffective and a diagnosis of intestinal obstruction was made. A nasal tube was passed and 400 c.c. of dark brown, malodorous gastric contents were withdrawn. Wangensteen suction was started and the patient was made comfortable. The following day she was operated upon and when the abdomen was opened a gush of clear fluid was seen. There were many loops of dilated small intestine. At the point where dilated bowel merged with collapsed bowel, a hard mass was palpated which, when removed by a transverse intestinal incision, proved to be a gallstone. This gallstone, which was 3 cm. in diameter, was rounded in contour except for one smooth facet. The gall bladder was palpated and found to be thickened and covered by omentum. No fistulous communication between the gall bladder and intestine could be felt. The common duct was felt by the surgeon to be enlarged and although the patient's condition would not permit direct visualization of the biliary tract it was his opinion that the gallstone had entered the intestinal tract via a dilated common duct. Another stone of nearly the same size was felt in the gall bladder. The postoperative course was uneventful and the patient recovered without, so far as is known, any subsequent difficulty due to the second gallstone.

The inclusion of Cases 33 and 36 as examples of gall bladder fistula (Niemeier type III perforation) may be open to question because in neither of the two cases was the fistula visualized. In Case 33 the fistula was not seen, possibly because a lower abdominal incision was used, and the gall bladder also was not seen, but a large faceted gallstone was present in the ileum, the gall bladder was surrounded by palpable adhesions, and in addition other stones were present in the gall bladder. All these factors lead us to believe that this is a case of biliary fistula. In Case 36 the fistula was also not seen, possibly because the gall bladder itself was not visualized, but a 3 cm. diametered faceted gallstone was found in the ileum and the gall bladder was surrounded by palpable adhesions. Despite the surgeon's impression that this gallstone entered the in-

testine by way of the dilated common duct, such a large stone must have caused erosion of either the ampulla of Vater, common duct wall, or gall bladder wall. Furthermore, if the two cases referred to in this paragraph are excluded they actually strengthen our main argument and we include them for completeness. Without them six out of nine intestinal obstructions due to gall bladder perforations (67 per cent) were caused by inflammatory mechanisms rather than by gallstone ileus. If the two cases are included, six out of eleven intestinal obstructions due to gall bladder (and bile duct perforations [?]55 per cent) were caused by inflammatory mechanisms rather than by gallstone ileus. In either instance the inflammatory obstructions represent a majority.

## DISCUSSION

Among all the causes of intestinal obstruction, perforations of the gall bladder are not common. On the other hand, in this series, intestinal obstruction occurred in nine of thirty-nine demonstrated perforations (23 per cent) and in eleven of a total of forty-one probable and demonstrated perforations (27 per cent). Because this condition is not often considered in the differential diagnosis of intestinal obstruction, it is frequently unrecognized when it does occur. Failure to make a correct diagnosis carries with it a high mortality, whereas the mortality rate may be low if the true pathologic state is suspected preoperatively.

In spite of the great reduction in the mortality from intestinal obstruction in general which has resulted from advances in fluid and electrolyte replacement (Hartwell and Hoguet, 1912; MacCallum, 1920; Haden and Orr, 1923; Coller, 1940; and others) and from the development of intestinal suction and intubation (Wangensteen, 1942; Miller and Abbott, 1934; and Johnston, 1940) there is still a considerable annual loss of life due to this condition. It is important, therefore, to be aware of all the unusual types of obstruction which are commonly overlooked. The additive effect of all the rare and unusual types of intestinal obstruction which are not commonly considered and therefore not frequently diagnosed early, and of which the present condition is a significant example, is almost as important in maintaining the present mortality of intestinal obstruction as are the factors of infection and strangulation.

Other writers (Waters, 1926; Bartlett and Bartlett, 1926; Greene and Coe, 1940; and Rankin and Eger, 1943) have mentioned intestinal obstruction in the differential diagnosis of their reported cases of perforation of the gall bladder. Occasional cases of actual mechanical intestinal obstruction associated with gall bladder perforations (exclusive of gallstone ileus) are to be found in the literature. For example, Edwards, Gerwig, and Guyton (1941) in reporting twenty-one cases of acute cholecystitis with perforation into the peritoneal cavity studied at the Church Home and Infirmary and at the University Hospital, Baltimore, described a case of a 59-year-old man who had suffered severe right upper quadrant pain for several years. He had noted continuous pain for more than twenty-four hours before being seen. On admission he was critically ill with vomiting and distention; skin was dry and jaundiced and the abdominal muscles were fairly rigid throughout. Tenderness was exquisite and diffuse and there

was a mass in the right upper quadrant. On exploration, the hepatic flexure of the colon was found to be densely adherent to the gall bladder and was obstructed. A perforation of the gall bladder had occurred just lateral to its fixation to the colon. Gallstones and bile were found in the free peritoneal cavity. When the gall bladder was dissected from the colon the obstruction was relieved.

In the present series of cases intestinal obstruction associated with perforation of the gall bladder was not due to gallstone ileus in six of nine established cases and in six of a total of eleven probable and established cases, but resulted from the inflammatory reaction or adhesions following perforation of the gall bladder. Perforation of the gall bladder should, therefore, be considered in the search for the cause of intestinal obstruction of obscure origin.

## SUMMARY

In a study of forty-one acute, subacute, and chronic gall bladder perforations, of which thirty-nine were confirmed at operation or autopsy, seen at this hospital on the surgical service over the last twenty years (twenty-nine cases), and at the autopsy table since 1889 (twelve cases), eleven cases (27 per cent of the total) were found to be associated with intestinal obstruction. Only five of these eleven cases (45 per cent) were instances of the classical gallstone ileus, three of which were confirmed by actual visualization of the fistula. The other six (55 per cent) were not due to the formation of cholecystenteric fistulas but rather to other mechanisms produced by acute or subacute gall bladder rupture. The relative rarity of these lesions and the obscurity of the symptoms produced by them led to a low percentage of correct diagnoses and to a high percentage of fatalities.

## CONCLUSIONS

Intestinal obstruction of obscure origin may sometimes be due to perforations of the gall bladder. In this series about one-fourth of such perforations resulted in intestinal obstruction. In puzzling cases, gall bladder disease should be considered in order that intestinal obstruction produced by gall bladder perforation be not overlooked.

In this series, intestinal obstruction due to gall bladder perforation was more often (55 per cent of all cases; 67 per cent of confirmed cases) due to acute or subacute perforations with resultant inflammatory paralytic or mechanical obstruction than (45 per cent of all cases; 33 per cent of confirmed cases) to chronic perforations with resultant classical gallstone ileus.

## REFERENCES

1. Atlee, J. L., and Atlee, J. L.: Acute Cholecystitis, Pennsylvania M. J. **44**: 731-734, 1941.
2. Baleh, F. G., Jr.: Gallstone Ileus, New England J. Med. **218**: 457-462, 1938.
3. Bartholin: Cited by Martin, F.: Intestinal Obstruction Due to Gall Stones, Ann. Surg. **55**: 725-743, 1912.
4. Bartlett, W., Jr., and Bartlett, R. W.: Perforation of the Gall Bladder With Massive Intraperitoneal Hemorrhage, J. A. M. A. **106**: 615-616, 1936.
5. Blain, A., III, and Kennedy, J. D.: The Effect of Penicillin in Experimental Intestinal Obstruction: Studies on Strangulated Low Ileal Obstructions, Bull. Johns Hopkins Hosp. **79**: 1-20, 1946.
6. Blalock, A.: A Statistical Study of Eight Hundred and Eighty-Eight Cases of Biliary Tract Diseases, Bull. Johns Hopkins Hosp. **35**: 391-409, 1924.

7. Borman, C. N., and Rigler, L. G.: Spontaneous Internal Biliary Fistula and Gallstone Obstruction, With Particular Reference to Roentgenologic Diagnosis, SURGERY **1**: 349-378, 1937.
8. Calihan, R. J., Kennedy, J. D., and Blain, A., III: Intestinal Obstruction: A Study of Two Hundred and Four Acute Cases With Reference to the Possible Efficiency of Anti-Bacterial Therapy, Bull. Johns Hopkins Hosp. **79**: 21-33, 1946.
9. Coller, F. A., and Maddock, W. G.: Water and Electrolyte Balance, Surg., Gynec. & Obst. **70**: 340-354, 1940.
10. Courvoisier, L. G.: Casuistrach-Statistisch Beiträge zur Pathologie und Chirurgie der Gallenwege, Leipzig, 1890, F. C. W. Vogel.
11. Cowley, L. C., and Harkins, H. N.: Perforation of the Gall Bladder: A Study of Twenty-five Consecutive Cases, Surg., Gynec. & Obst. **77**: 661-668, 1943.
12. Dennis, C., and Brown, S.: Small Bowel Obstruction, Staff Meeting Bulletin, Univ. of Minnesota, Jan. 23, 1942.
13. Edwards, C. R., Gerwig, W. H., and Guyton, W. L.: Acute Cholecystitis With Perforation into the Peritoneal Cavity, Ann. Surg. **113**: 824-832, 1941.
14. Finney, G. G.: In discussion of paper by Foss and Summers, 1942 (loc. cit.).
15. Fitz, R.: The Diagnosis and Medical Treatment of Acute Intestinal Obstruction, Trans. Cong. Am. Phys. & Surg. **1**: 1, 1888: Cited by Wangensteen, O. H.: Intestinal Obstructions, Springfield, Ill., Charles C Thomas, 1942.
16. Foss, H. L., and Summers, J. D.: Intestinal Obstruction From Gallstones, Ann. Surg. **115**: 721-735, 1942.
17. Glenn, F., and Moore, S. W.: Gangrene and Perforation of the Wall of the Gallbladder: A Sequela of Acute Cholecystitis, Arch. Surg. **44**: 677-686, 1942.
18. Greene, E. I., and Coe, G. C.: Acute Free Perforation of the Gall Bladder Occurring Twice in the Same Patient, SURGERY **7**: 396-400, 1940.
19. Haden, R. L., and Orr, T. G.: Chemical Changes in the Blood of the Dog After Obstruction of the Duodenum, J. Exper. Med. **37**: 365, 1923.
20. Harkins, H. N., Harmon, P. H., and Hudson, J. E.: Peritonitis Due to Bile and to Liver Autolysis, J. A. M. A. **107**: 948-952, 1936.
21. Harkins, H. N., Harmon, P. H., and Hudson, J.: Lethal Factors in Bile Peritonitis. I. Surgical Shock, Arch. Surg. **33**: 576-608, 1936.
22. Harper, H. W., and Blain, A., III: The Effect of Penicillin in Experimental Intestinal Obstruction: Preliminary Report on Closed Loop Studies, Bull. Johns Hopkins Hosp. **76**: 221-244, 1945.
23. Hartwell, J. A., and Hoguet, J. P.: Experimental Intestinal Obstruction in Dogs With Special Reference to Cause of Death and Treatment by Large Amounts of Normal Saline Solution, J. A. M. A. **59**: 82, 1912.
24. Hicken, N. F., and Coray, Q. B.: The Perforating Gall Bladder, Rocky Mountain M. J. **40**: 524-529, 1943.
25. Hotz, R.: Perforated Cholecystitis, Am. J. Surg. **44**: 706-711, 1939.
26. Johnston, C. G.: Decompression in the Treatment of Intestinal Obstruction, Surg., Gynec. and Obst. **70**: 365-369, 1940.
27. Judd, E. S., and Burden, V. G.: Internal Biliary Fistula, Ann. Surg. **81**: 305-312, 1925.
28. Leichtenstern, L.: Verengerungen. Verschliessungen und Lageveränderungen des Darms, Von Ziemssens Handbuch. 7 (part 2): 1876: Cited by Wangensteen, O. H.: Intestinal Obstructions, Springfield, Ill., Charles C Thomas, 1942.
29. Leigh, O. C., Jr., Nelson, J. A., and Swenson, P. C.: The Miller-Abbott Tube as an Adjunct to Surgery of Small Intestinal Obstructions, Ann. Surg. **111**: 186-212, 1940.
30. Lewis, E. J., Shapiro, P., and Vaughan, R. T.: The Management of Mechanical Obstruction of the Small Intestine Due to Bands and Adhesions, J. A. M. A. **114**: 2350-2354, 1940.
31. MacCallum, W. G., Lintz, J., Vermilye, H. N., Leggett, T. H., and Boas, E.: The Effect of Pyloric Obstruction in Relation to Gastric Tetany, Bull. Johns Hopkins Hosp. **31**: 1, 1920.
32. Martin, F.: Intestinal Obstruction Due to Gall Stones, Ann. Surg. **55**: 725-743, 1912.
33. Mentzer, S. H.: Obstructive Cholecystitis: With Particular Reference to Acute Obstructive Cholecystitis and Its Sequelae, Surg., Gynec. & Obst. **62**: 879-886, 1936.
34. Miller, T. G., and Abbott, W. D.: Intestinal Intubation: A Practical Technique, Am. J. M. Sc. **187**: 595-599, 1934.
35. Moore, G. A.: Gall Stone Ileus, Boston M. & S. J. **192**: 1051-1055, 1925.
36. Niemeier, O. W.: Acute Free Perforation of the Gall Bladder, Ann. Surg. **99**: 922-924, 1934.
37. Pennoyer, G. P.: Results of Conservative Treatment of Acute Cholecystitis, Ann. Surg. **107**: 543-557, 1938.
38. Powers, J. H.: Acute Intestinal Obstruction Due to Impacted Gall Stones: Report of Four Cases, Surg., Gynec. & Obst. **47**: 416-420, 1928.

39. Proceedings of the Section on Surgery at the Annual Meeting of the British Medical Association, Brit M. J. **2**: 993, 1925.
40. Rankin, L. M., and Eger, S. A.: Acute Spontaneous Perforation of Gallbladder, Am. J. Surg. **61**: 300-301, 1943.
41. Rigler, L. G., Borman, C. N., and Noble, J. F.: Gallstone Obstruction: Pathogenesis and Roentgen Manifestations, J. A. M. A. **117**: 1753-1759, 1941.
42. Robson, Mayo: Gall Bladder and Bile Ducts, ed. 3, New York, William Wood & Co., 1904.
43. Sanders, R. L.: Perforation of the Gallbladder, SURGERY **1**: 949-958, 1937.
44. Schaeffer, R. L.: Acute and Chronic Perforations of the Gallbladder, Pennsylvania M. J. **45**: 565-569, 1942.
45. Schlicke, C. P., Bargen, J. A., and Dixon, C. F.: Management of Intestinal Obstruction; Evaluation of Conservative Therapy, J. A. M. A. **115**: 1411-1416, 1940.
46. Smith, U. R.: Acute Intestinal Obstruction Due to Gallstone, Brit. M. J. **2**: 479, 1925.
47. Stone, W. W., and Douglas, F. M.: Perforation of the Gallbladder, Am. J. Surg. **45**: 301-303, 1939.
48. Storck, A., Rothschild, J. E., and Ochsner, A.: Intestinal Obstruction Due to Intraluminal Foreign Bodies, Ann. Surg. **109**: 844-861, 1939.
49. Vick, R. M.: Statistics of Acute Intestinal Obstruction, Brit. M. J. **2**: 546-548, 1932.
50. Vidgoff, I. J.: Acute Intestinal Obstruction Due to Gallstones, Am. J. Surg. **19**: 458-461, 1933.
51. Wangensteen, O. H.: Intestinal Obstructions, Springfield, Ill., Charles C Thomas, 1942.
52. Waters, E. G.: Perforation of the Gallbladder, Intraperitoneal Hemorrhage; Report of a Case, M. J. & Rec. **123**: 11, 1926.

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## Urology Award

The American Urological Association offers an annual award "not to exceed $500" for an essay (or essays) on the result of some clinical or laboratory research in urology. Competition shall be limited to urologists who have been in such specific practice for not more than five years and to residents in urology in recognized hospitals.

For full particulars write the secretary, Dr. Thomas D. Moore, 899 Madison Avenue, Memphis, Tenn. Essays must be in his hands before May 1, 1947.

The selected essay (or essays) will appear on the program of the forthcoming meeting of the American Urological Association, to be held at the Hotel Statler, Buffalo, N. Y., June 30 to July 3, 1947.

# Review of Recent Meetings

## TWENTY-SIXTH MEETING OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

DETROIT, MICH., MAY 29-31, 1946
F. C. FISHBACK, M.D., WASHINGTON, D. C.

**The Management of Thoraco-Abdominal War Injuries, Reeve H. Betts,** Boston.—The mortality rate of thoraco-abdominal injuries was reduced from the 50 to 60 per cent of World War I to a level comparable to straight abdominal injuries by the utilization of adequate anesthesia, the transthoracic approach, the preoperative restoration of disturbed cardio-respiratory physiology, adequate blood replacement, before, during, and after operation, and the maintenance of a clear airway at all times. In these wounds, the diaphragm is always injured. A defect in the diaphragm will produce a sucking wound. The diagnosis may be obvious or very difficult. Thoracic wounds may produce abdominal pain and muscle spasm. Absent peristalsis may indicate bowel injury, but is not reliable. A wound as high as the fourth rib anteriorly may penetrate the abdomen. Ninety per cent of chest wounds may involve the belly; ten per cent of abdominal wounds may penetrate the chest. In penetrating chest wounds, an intact diaphragm eliminates intra-abdominal injury. Thoracotomy permits the prompt restoration of normal intrathoracic physiology, which lessens shock. Large intravenous infusions should be avoided; when given, they should be run in slowly. The approach to these wounds should be individualized. The transthoracic approach affords better exposure for lesions of the spleen, stomach, splenic flexure of the colon, and dome of the liver. Repair of the diaphragm is easier from above; the pleura is more easily washed out, and there are fewer postoperative pulmonary complications. Celiotomy is necessary for repair of injuries to the cecum, lower portions of the colon, and sigmoid. Separate incisions may be used, or the thoracotomy incision may be extended downward across the costal margin. More rapid re-expansion of the lung is obtained without underwater drainage, but frequent pleural aspiration may be necessary. A clear airway is maintained at all times by catheter aspiration or bronchoscopic drainage. The mortality in these cases parallels the severity of the wounds. The mortality from right-sided wounds is lower than from left-sided wounds. Pulmonary complications accounted for more deaths than did abdominal complications. Prompt re-expansion of the lung and a clear airway reduced pulmonary complications. Deaths on the first post-operative day were often associated with a uremic syndrome, the result of prolonged shock and concomitant renal anoxia. The mortality in the forty-eight cases reported by **Dr. Betts** was 22.9 per cent.

In the discussion, **Col. James H. Forsee** mentioned the lack of statistics for these combined wounds in World War I, but pointed out that abdominal wounds alone carried a 66 per cent mortality in 1918. In World War II, 1,500 exclusively thoracic wounds carried a mortality of only 7 per cent. **Dr. Evarts Graham** suggested that the complication of uremia might be the result of the use of incompatible blood in transfusion. **Dr. George Finney** said that in the Okinawa campaign, 40,607 pints of blood (O type) were used without cross-matching, and with but two immediate reactions. **Dr. Frank Berry** stated that in the event of urgent need for a transfusion, an O type blood of low titer was best; he emphasized that all blood should be refrigerated. **Dr. Emile Holman** said that these post-transfusion deaths with anuria were the result of hemolysis, hemoglobinuria, and the production of hemo-

Several papers, including the Presidential Address, have appeared in the October, 1946, issue of the Journal of Thoracic Surgery.

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globin casts which plugged the renal tubules. **Dr. E. D. Churchill** questioned seriously whether the transfusions were responsible for renal failure. He cited the similarity to crush syndrome, in which pigment (myohemoglobin) nephropathy occurred, with tubule obstruction, anoxia, and diffuse cortical necrosis. He aptly said that "like Caesar's wife, blood for transfusion, must be above suspicion." In closing, **Dr. Betts** said that only 25 per cent of these wounds were due to rifle bullets, the remaining 75 per cent being caused by high explosive, shell, and bomb fragments.

**Crushing Injuries of the Chest, Ross Robertson,** Vancouver, B. C.—These occurred in the Royal Canadian Air Force. Deaths were due to hemorrhage, cardiac tamponade, or respiratory failure from mechanical asphyxia. Cardiac tamponade was the commonest preventable cause of death. Any one or a combination of the following conditions could be present: (1) blood obstructing the airway, (2) flapping chest wall, (3) hemothorax, (4) tension pneumothorax, (5) massive atelectasis, (6) mediastinal hematoma and/or emphysema, (7) hemopericardium, (8) diaphragmatic hernia, (9) gastric dilatation, and (10) air embolism. If the airway was obstructed, it was cleared and oxygen was given (8 to 10 liters per minute). The chest was immediately x-rayed, using a portable machine. The unstable chest wall was supported by strapping. Fluid losses were replaced with whole blood and saline, even at the risk of pulmonary edema. Hemothorax was aspirated only if cardiac tamponade was present, and then only in amounts sufficient to relieve pressure symptoms. If possible, he avoided aspiration for three or four days, since it was his belief that the blood in the pleural space tended to stop bleeding. If the lung failed to re-expand after aspirating, clotting was presumed to have occurred and this was treated by catheter suction drainage or early decortication. It should be pointed out that **Dr. Robertson** was using "tamponade" to mean interference with the filling of the heart, rather than the more usual meaning of compression of the heart. In cardiac tamponade from tension pneumothorax, relief was obtained by intercostal catheter drainage, slowly, through a water seal. When tamponade was due to massive atelectasis, he advocated induction of an artificial pneumothorax to relieve the great negative pressure, and later that the bronchial obstruction be cleared. It should be needless to say that artificial pneumothorax is not the accepted treatment for atelectasis. In the discussion, **Dr. Alfred Blalock** urged that venous pressure determination and fluoroscopy were valuable adjuncts in the diagnosis of cardiac tamponade. **Dr. Claude Beck** reiterated his belief that compression of the heart was a more correct term than cardiac tamponade. **Dr. Brodie Stephens** said that early aspiration was the best treatment for hemothorax: and that pulmonary bleeding will usually stop by itself, thanks to the low head of pressure in the pulmonary circuit.

**The Pathology of Chronic Hemothorax, Hiram T. Langston,** Chicago.—Frequently, a traumatic hemothorax is not reducible by thoracentesis, because of clotting of the pleural content, caused by the presence of fibrin. Accumulated evidence suggests that the explanation of this clotting is the response of the pleura to the inciting trauma and the presence of blood which is a pleural irritant. Thus trauma and blood serve as an adequate source of fibrin. The wounded tissues, whether lung or muscle or both, affords ample thromboplastic material. Once clotting has occurred, organization ensues, resembling exactly the formation of intravascular thrombi. Clotting occurs within three to five days, if it is going to occur. Bacteria, which are often present, cause an exudative pleural response. Traumatic pneumothoraces with slow pulmonary re-expansion may be regarded as minimal instances of this process. Neglected, gross, organizing hemothorax will become either a fibrothorax ("respiratory cripple") or will eventually suppurate. The time lag required for the organization of new blood vessels to penetrate the fibrin mass far enough to allow leukocytes migrating from this point to collect in sufficient numbers to be recognizable as pus, accounts for the delay in suppuration. The older, outer portion of the clot contains much fibrin and exhibits only a minor leukocytic response. Suppuration occurs first in the inner portion of the clot. The obvious result of neglect, procrastination, or failure to recognize this condition, permits such advanced organization along the visceral pleura that the lung is encased in a cuirass of fibrous tissue so dense that expansion cannot occur, and a persistently infected pleural space results.

**The Treatment of Organizing Hemothorax by Pulmonary Decortication, W. M. Tuttle,** Detroit.—Decortication is an old operative procedure, which was discarded after a relatively short trial because of poor results. The conventional treatment of hemothorax had been repeated aspirations, but there was a residual of five to ten per cent in which empyema or crippling fibrothorax occurred. In 1942, Smithy had noted the high incidence of invalidism in these cases; the x-ray showed a fluid level but aspiration yielded no fluid and the patient had a contracted chest. The first decortication for organizing hemothorax was done in the African campaign (1943) by Major Thomas H. Burford. **Dr. Tuttle** reported the results of decortication in 140 cases; there were no deaths in the series. Fifty-one presented gross infection, and eighty-nine did not. Two-thirds of these patients had combined thoracoabdominal injuries. Seventy-five per cent were due to shell fragments. Two instances occurred without wounds, due to contusion. Seventy-seven per cent re-expanded within 48 hours after operation, 18.6 per cent re-expanded within five to six days, and only 4.3 per cent failed to re-expand or developed a fistula. Four and three-tenths per cent returned to active duty, 45 per cent to limited duty, 31.4 per cent were returned to the zone of interior because of their chest conditions, and 16.4 per cent because of extrathoracic conditions. Decortication is easy in the uninfected cases, but difficult in the infected ones. There were only two wound infections in this series. In the fifty-one infected patients (empyemata), primary healing occurred in 49.1 per cent, eventual healing in 45.1 per cent, with a small residual group of only 5.8 per cent having a chronic empyema or bronchopleural fistula. The operation should be done within three to four weeks after injury. Prompt decortication assures an easier convalescence and lower risk of empyema. He emphasized the importance of freeing fissures, getting the lung off the mediastinum, and removing the constricting fibrous sheath so that the lung re-expands to fill the chest at the time of the operation. He used two drainage tubes.

**Total Pulmonary Decortication: Its Evolution and the Present Concept of Indications and Operative Technique, Paul C. Samson,** Oakland, Calif.—Delorme used the term "decortication" first in 1896, although it is improbable that he conceived of the process as peeling off an inflammatory membrane from the pleura. In 1893, Fowler performed an operation for chronic empyema which involved freeing of a constricting membrane. Delorme reported in 1894 two cases, one in 1892 and another in 1893, stating in the latter that he removed a membrane from the pleura. There have been many modifications since then. It was usually carried out with open drainage and irrigations. In 1915, Howard Lilienthal described an operation for acute empyema in which he freed the lung from the diaphragm but not the mediastinum, pointing out that the pyogenic membrane can be stripped off the normal pleura. Moynihan described freeing up the lung when removing a foreign body. Decortication has usually been accompanied by much bleeding. In organizing hemothorax, the pleura remains thin, while the fibrous coat which encircles and parallels the pleura becomes progressively thicker and may even become calcified; the presence of air seems to be conducive to an even thicker fibrous coat. Delay in operation makes decortication more difficult, or even impossible. The chest is opened through a posterolateral incision in the sixth interspace, the liquid or semiliquid clot evacuated, and then decortication is begun with a sharp incision to the visceral pleura. The lung herniates through this incision, and further dissection is carried out with the finger or a peanut dissector. The lung is freed from the mediastinum and diaphragm, and the fissures are separated. Tears in the pleura or lung should be repaired. When pulmonary abscess is present, segmental or wedge resection of the lung is carried out. Three rubber tube drains are inserted, one in the eighth interspace in the posterior axillary line, another in the eighth interspace in the midclavicular line, and a third in the second interspace in the midclavicular line. The chest is flushed out with saline, the lung re-expanded, and the chest wall is then closed in layers. Penicillin is instilled through the upper anterior tube, but no irrigations are done. The tubes are connected with a water trap and the patient is encouraged to breathe deeply. The chief indication for decortication is organizing hemothorax after failure of repeated aspirations. The x-rays show a hazy chest with signs of fluid. There is poor expansion of the chest and contraction of the interspaces. In this series of approximately 150 patients, 25 per cent were grossly infected, and in every instance the

lung re-expanded and there were no chronic empyema. Infected organizing hemothoraces should be operated on as soon as possible. In post-traumatic empyema, decortication in indicated rather than rib resection. The rationale of the operation is the early restoration of normal pulmonary function. The "peel" which is removed is not part of the pleura, which remains normal.

In the discussion, **Dr. J. M. Chamberlain** said to excise the parietal peel last and emphasized the benefits of early ambulation, even getting the patient up on the day following operation, with the resulting prompt restoration of function. **Dr. Paulson,** in commenting on the difficulty of getting off the visceral peel, said that he removed the parietal peel first, then freed the diaphragmatic pleura, after which he found the visceral peel came off easily. He said he had also carried out decortication for tuberculous pleuritis. **Dr. Carl Eggers** pointed out that organizing hemothorax is the result of battle casualty, in contrast to the chronic empyemas seen after the last world war, which were the chronic residues of acute infections of the pleura. He recalled how the ribs were embedded in the grossly thickened parietal pleura so firmly that it was impossible to insert a rib spreader, while the visceral pleura layer was relatively thin. Referring to chronic empyema, he felt that an effort should be made to mobilize the lung, especially at the angle of reflection from the chest wall. **Dr. E. F. Butler** concurred with **Dr. Eggers** and said that decortication was exceedingly difficult in the old, long established case. Early decortication, preferably within thirty days, facilitates the dissection and minimizes the danger of a crippling fibrothorax. **Dr. Fraser Gurd** stated that he had used decortication in cases of chronic empyema for many years. He added that he had used chemical decortication with sodium hypochlorite to remove the fibrin mass, many times. **Dr. E. D. Churchill** recalled that in the army manual on thoracic surgery, which he assisted in compiling, no mention was made of decortication. In the past, a generalized empyema was permitted to localize and then drained. He believes that early decortication represents a new and valuable principle in surgery of the chest; namely, the conversion of a localized empyema into a generalized empyema, with theoretic contamination of the whole pleura, but effectively producing a complete re-expansion of the lung which obliterates the empyema cavity. Re-expansion is more important than drainage in that it restores function and eliminates the need for drainage by collapsing the empyema pocket. **Dr. Evarts Graham** said that these hemothoraces and empyema were different, that empyema was an abscess of the pleural cavity and that a hemothorax was not. He felt that the latter represented a pleural infection, attenuated by chemotherapy. **Dr. Tuttle** said that an infected hemothorax was an empyema because the chest contained foul pus and the patients ran a septic fever. He pointed out that decortication antedated the use of penicillin and restated his position that the important thing was adequate re-expansion of the lung. **Dr. Samson** said that he did not remove the parietal pleura routinely.

**Thoracic Neoplasms in Navy Personnel, W. L. Watson,** New York.—During the years of 1943, 1944, and 1945, 746 cases of cancer and allied diseases (neoplasms) were admitted to the Tumor Service of the Naval Hospital at Brooklyn, N. Y., of which thirty-four were intrathoracic neoplasms. Eight cases of mediastinal Hodgkin's disease and two of malignant thyoma were treated by radiation. From a group of twenty-five patients with intrathoracic tumors that were treated surgically, fourteen were discovered fortuitously by x-ray. In this latter group were two cases of bronchial adenomata treated by pneumonectomy, one case of a schwannoma treated surgically after failure with x-ray; a benign lymphoma treated surgically, a left sided teratoma which was excised, a bronchogenic carcinoma treated by pneumonectomy, a capillary hemangioma (or mesothelioma) treated by pneumonectomy, and another bronchogenic carcinoma treated by lobectomy (patient died within four months). The speaker urged routine periodic x-rays of the chest.

**Pulmonary Cysts, Herman J. Moersch,** Rochester, Minn.—He presented forty-four cases of surgically proved pulmonary cysts and classified them in three groups. Group 1 (twenty-five cases), cysts lined with epithelium and having walls containing cartilage, muscle, glands, and other bronchial elements; Group 2 (eleven cases), cysts similar to those in Group 1, ex-

cept that the epithelial lining had been destroyed or altered by infection; Group 3 (eight cases), exhibited marked localized dilatation of the bronchi and were termed cystic bronchiectasis. The series consisted of twenty-four males and twenty females; the ages ranged from 7 years to 58, with an average age of 30. The right lung was more frequently involved than the left (28:16), and the majority of the cysts were single, only four being multiple. He said that pulmonary cysts are not always congenital in origin and that infection often plays an important role in their development. The commonest symptoms associated with these cases were cough, expectoration, hemoptysis, and pain. Seven of these cases were asymptomatic; they were discovered accidentally. The difficulty of diagnosis, even with a suggestive clinical history, is emphasized by the fact that twelve of these cases had been misinterpreted previously. X-ray examination is the most valuable aid in the diagnosis of pulmonary cysts. Bronchoscopy and bronchography were of little value except in cases of cystic bronchiectasis. Infected pulmonary cysts should be removed surgically not only for local reasons but because of deleterious effects on other organs. Carcinoma was found in the walls of two of these cysts, and this affords an additional reason for prompt surgical removal. It seemed probable that the carcinoma was secondary to changes in the epithelial lining of the cysts.

In the discussion, **Dr. Evarts Graham** said that pulmonary cysts are not so rare as many have believed; they are usually found in children and young people, and seldom beyond middle age. Early diagnosis should assure surgical removal before the cyst becomes infected or undergoes malignant change. It is well known that congenital abnormalities tend to take on malignant changes. Cystic diseases of the lung should be regarded as potentially malignant. **Dr. W. E. Adams** pointed out the difficulties in differential diagnosis of lung cysts, and said that they might be confused with bronchiectasis, lung abscess, empyema, tuberculosis, pneumothorax, and diaphragmatic hernia. **Dr. Robert Gross** reported the removal of a lung in a 2-week-old infant for pulmonary cyst. Dr. Jerome Head said that these congenital cysts are often lined with ciliated epithelium, and that they always have a separate blood supply coming directly off the aorta. **Dr. Ballon** said that pulmonary cysts in infants can be treated successfully by aspiration alone.

**Report of the Chest Tumor Registry, J. E. Ash,** Col. M. C., Curator, Army Medical Museum.—More than 600 cases have been registered to date, complete with history and x-rays. The mechanics of registration consist of sending slides, tissues, and history as well as x-rays. The speaker reported that the list of tumors registered thus far consisted of twenty-nine mediastinal teratomas, seventeen teratomas of the lung, 665 carcinomas of the lung, 104 carcinomas of the bronchi, six superior sulcus tumors, sixty-four cysts, twenty-three neurofibromas, thirty-eight (or thirty-nine) bronchial adenomas, and thirty-two cases of tuberculosis for which lobectomy had been done.

**A Report of 194 Lobectomies Performed at Kennedy General Hospital, Chest Surgical Center—1943-1946, with One Death, R. H. Meade, Jr.,** Chicago.—Although most of these patients were battle casualties, their treatment presented few problems due to the excellent care given them overseas. Three surgeons did most of the operations but some were done by three others. **Dr. Meade** actually reported 196 lobectomies, done in 190 patients, four patients having bilateral lobectomies and two having a second lobectomy on the same side. Bronchiectasis was the indication for 161 lobectomies, pulmonary cyst for twenty-two, suppuration for seven, adenoma for three, actinomycosis for three, tuberculosis for two, neurosarcoma for one, carcinoma for one, and adenomatosis for one. Bronchiectasis was unilateral in 129 cases and bilateral in 27. The single death in the series occurred in a case of bilateral bronchiectasis, and was caused by pulmonary and cerebral edema. On the left side, 126 lobectomies were done, with eighty-five being confined to the lower lobe and thirty-five to the middle and lower lobes. On the right side there were seventy lobectomies, with thirty-seven involving the lower lobe, thirteen the middle lobe alone, and sixteen the middle and lower lobe. Penicillin, 100,000 units, was given intramuscularly every three hours prior to operation; even larger doses were used in the presence of known infection. He emphasized the importance of (1) endotracheal anesthesia, assuring a clear airway; (2) the satisfactory exposure gained by the use of the lateral approach through a rib bed, preferring the bed of the sixth

or seventh rib for the lower lobe; (3) individual ligation technique; (4) careful closure of the bronchial stump with interrupted silk sutures over which was placed a pleural graft; (5) water seal drainage until the lung has re-expanded; (6) penicillin locally within the chest, and also intramuscularly until re-expansion occurs; (7) routine bronchoscopy immediately after the operation; and (8) oxygen for ten to eighteen hours after operation. He suggested the use of phrenic nerve interruption after extensive pulmonary resection where the patient complained of pain or a severe sense of tightness of the chest. Fifteen of the patients developed empyema, eleven with fistulae and four without. The other complications consisted of seven cases of jaundice, two of pneumothorax, one of hemothorax, one of atelectasis, and one cerebrovascular accident. He advocated the importance of teamwork in assuring success.

In discussing this paper, **Dr. R. H. Overholt** said that bronchiectasis was not a lobar but a segmental disease and that 30 per cent of these cases were bilateral. He urged the consideration of the pulmonary segment as a surgical unit, adding that branches of bronchi and pulmonary arteries do not cross intersegmental planes. **Dr. Meade,** in closing, said that the series now consisted of 236 lobectomies. He stressed the fact that the prime indication for lobectomy in bronchiectasis was the existence of symptoms, and not merely a suggestive bronchogram. In some patients, symptoms began with an attack of virus pneumonia; in others, symptoms had been present many years.

**Pulmonary Function After Adolescence Following Pneumonectomy in Childhood, Charles Lester,** New York—Dr. Lester stated that this paper constituted a progress report on the cases which he had reported at the Toronto meeting in 1941, with observations on one additional case. He had also included observations made on cardiac output and right ventricular pressure, using the technique of right heart catheterization (insertion of catheter through median basilic vein to the right auricle). All four patients had had their left lung removed. Two presented their tracheas in the midline, in one there was a shift of the trachea and in one the esophagus had moved over. Small pneumothoraces were noted on the left side in the cases with the trachea still in the midline. The lungs had continued to grow but would not equal the combined volume of the two good lungs. Residual air had increased as the lung volume expanded. Distention of the lung may reduce the maximum breathing capacity to 55 per cent. Oxygen saturation of the arterial blood is normal with the patient at rest and the lung undistended; with distention of the remaining lung, oxygen saturation falls to 83 to 86 per cent. Cardiac output and pressure within the right heart remain essentially normal. When distention of the remaining lung occurs, dyspnea ensues, and exhaustion comes on earlier.

**Dr. Edgar Davis** told of a 43-year-old pilot, on whom he had performed pneumonectomy for cancer of the lung, who was able to be carried to a simulated 22,500 feet in a pressure chamber before noting any changes; the first thing noted at that altitude was an abnormality of hearing. **Dr. Andre Cournand,** the co-author of the paper, closed the discussion, saying that one-half of these patients in whom pneumonectomy has been performed show some pulmonary distention, which is, however, a mechanical, not a compensatory phenomenon. With excessive strain and dyspnea, distention does occur, and produces anoxia. Pressures in the pulmonary vascular circuit do not increase, the adjustment being affected either by increased rapidity of blood flow or increased capillary diameters. Arterial oxygen saturation is inadequate under stress because of deficient alveolar ventilation or inefficient gas diffusion.

**The Use of Curare in Anesthesia for Thoracic Surgery, Phyllis Harroun,** San Francisco.—Curare has been used routinely in intrathoracic operations at the University of California Hospital since February, 1945. This paralyzing agent may be delivered to patients intravenously during operations. This report described the course of seventy-five patients to whom large doses (200 mg. to adults and 40 to 60 mg. to children) were given at the time of introduction of the intratracheal tube. Curare in these doses produces apnea and permits control of the respiration by the anesthetist. Nitrous oxide and oxygen were the anesthetic agents, and the high frequency cautery could be utilized throughout the entire operation. The patients showed little change from the normal during operations that averaged five and a

quarter hours. The patients awake soon after the termination of the anesthesia. The speaker emphasized that fears of curare, even in large doses, were groundless. In the discussion, **Dr. J. A. Weinberg** endorsed this method of anesthesia, emphasizing the advantage of being able to use coagulation throughout an operation but advised that curare be kept at a minimum, and suggested using pentothal as an adjunct. Atelectasis would not occur if the breathing were as regular and vigorous when the patient left the operating room, as when he entered. **Dr. Dorner** said that most postoperative pulmonary complications would be eliminated if routine bronchoscopic drainage were carried out. **Dr. H. B. Stephens**, the co-author, said that this was the best anesthesia he had encountered, and that in this group of cases, no instance of massive atelectasis had occurred.

**Surgery of the Thymus in Myasthenia Gravis, O. T. Clagett,** Rochester, Minn.—The co-existence of a thymic tumor and myasthenia gravis was first reported in 1901, although it was not until 1936 that a case of myasthenia gravis was cured by removal of a thymic tumor. This success led to the removal of a thymus without a tumor, by Blalock in 1939. The course of myasthenia gravis is unpredictable, being characterized by remissions and exacerbations. Of the 191 cases of myasthenia gravis seen at the Mayo Clinic, thirty-two have been operated on. Fifteen of these have had thymic tumors and seventeen showed only thymic hyperplasia. In the tumor group, eleven were men and four were women; in the hyperplasia group, twelve were women and only five men. There was one death in each group. Although Keynes had stated that those cases with thymic tumor offered a poor prognosis, in this series of cases the results were better in those patients with tumor than in those with hyperplasia. The impression is gained that those patients who have been operated on do better than those not operated on. The benefit of surgery may not appear until some time after operation. The optimum dose of neostigmine should be determined and used since this will help the patient to eat and reduce the possibility of aspiration. Preoperatively, the patient should be hospitalized to permit rest and a prophylactic course of penicillin. Sedation should be kept at a minimum. For twenty-four to forty-eight hours after operation, the patient should either be given oxygen or placed in a respirator. Endotracheal anesthesia, augmented at times by local anesthesia is essential. The operation appears to produce little shock. Either a vertical sternal-splitting incision or a posterolateral incision may be used. The thymus is a pinkish yellow, bilobular gland, overlying the pericardium and extending upward toward the neck, anterior to the innominate vessels. The critical period is that immediately after operation. If the patient appears anxious, he should be placed in a respirator. An aspirating set should be kept at hand if there is difficulty in raising secretions. The patient may be tube fed. Early ambulation, i.e., by the third or fourth postoperative day, is customary. Pathologically, some of the thymic tumors proved to be lymphosarcoma, and some carcinoma; some were encapsulated and some were invasive; only contiguous lymph nodes were involved, and there was no spread outside the thoracic cage. These tumors do not respond to x-ray therapy. The thymic hyperplasia of myasthenia gravis might be contrasted with the hyperplastic thyroid of hyperthyroidism.

**Dr. Blalock** said, in the discussion, that since 1941, he had done total thymectomies; prior to that time, only partial thymectomy had been done. He told of two of his patients who had eventually died, where at necropsy small pieces of thymus were found which had been overlooked at the time of operation. The fact that some patients still die after total thymectomy sustains his belief that the thymus is not alone to blame. He said, however, that the operation offers the best treatment for myasthenia gravis of short duration. When the course of the disease has been prolonged, the results are not so good and suggest that some irreversible change has occurred. **Dr. W. E. Adams** reported seven patients operated on, without tumor, where the degree of improvement was greater in the estimation of the patient than the surgeon. Operation sometimes reduced the need for prostigmine. He felt, however, that the thymus was but one link in the chain of etiology. His observation that myasthenia gravis did no occur after the menopause, and that with pregnancy, patients improved, made him consider whether some toxic substance existed in the menses. **Dr. Oschner** spoke of the relationship of the thyroid and thymus and pointed out that hyperthyroidism may offset the effects

of hyperactivity of the thymus. **Dr. R. Sweet** stated that thymic tumors occur without myasthenia gravis. **Dr. W. A. Hudson** reported a four-year cure after thymectomy where the disease had occurred one year after the menopause. **Dr. Clagett** said that few people have thymic tumor without having myasthenia gravis.

**Surgical Lesions of the Esophagus Seen in an Army Thoracic Center, Earle B. Kay,** Memphis.—During the past three years, over 130 patients with diseases and injuries of the esophagus were seen at this center. Forty operations were performed with one death (2.5 per cent). There were twenty-seven strictures, fourteen of which were due to the ingestion of caustics, and eleven of these were caused by sabotaged alcoholic beverages consumed accidentally while overseas. Twenty-one of these strictures were effectually dilated. Of the six with undilatable esophageal strictures, two had antethoracic esophagoplasties, and four had intrathoracic esophagoplasties. Of the latter, two were total and the other two were at the level of the thoracic arch. There were eight benign intramural esophageal cysts and tumors, of which seven were excised locally, while the eighth required resection and esophagogastric anastomosis. Out of five malignant tumors, three were inoperable and two were treated by resection and esophagogastric anastomosis. There were ten patients with traumatic injuries to the esophagus and eight others had large shell fragments adjacent to the esophagus, two of which had caused localized perforations or diverticuli. Eleven cases of cardiospasm, refractory to the usual dilatations were cured by cardioplasty. A marked decrease in the caliber of the esophagus was noted after operation. Twenty instances of congenital short esophagus were encountered; epigastric and nocturnal pain was frequently observed in this group. In the discussion, **Dr. R. Sweet** advocated the exclusive use of the thoracic incision for all surgery on the esophagus, and urged that the antethoracic esophagoplasty be abandoned for the intrathoracic type of operation. In the treatment of cardiospasm, he favored a long incision, with transverse closure. **Dr. F. R. Harper** spoke of the remarkable exposure gained by a thoracic incision through the ninth rib bed when it was carried across the costal margin, and suggested its use for exploration of tumors of the adrenal. **Dr. Kay,** in closing, urged the use of intrathoracic esophageal reconstruction.

**Technical Problems in Surgical Treatment of Carcinoma of the Esophagus and Upper Stomach, John H. Garlock,** New York.—A certain degree of standardization has resulted from the review of ten years' experience with surgery for malignancy of the lower esophagus. Adequate preparation before operation reduces postoperative complications. Such preparation includes the use of penicillin both intramuscularly and by nebulization, a thorough dental clean-up, repeated irrigations of the esophagus, and the correction of vitamin, electrolyte, and nutritional deficiencies, particularly hypoproteinemia, as well as dehydration. Endotracheal anesthesia is essential because it permits complete control of the patient's respiration and routine bronchial aspiration. The Torek operation has been supplanted by intrathoracic esophagectomy where continuity is re-established by bringing the fundus of the stomach up in the chest, even as high as the apex, and anastomosing it to the proximal esophageal remnant. The stomach is mobilized by closure of the cardia and ligation of the left gastric artery, the vasa brevia, and probably some of the left gastroepiploic vessels. The upper end of the esophagus derives its blood supply from the inferior thyroid arteries. The esophagus is exposed through a left thoracic incision of the sixth interspace, and division of the posterior ends of the fourth, fifth, seventh, and eighth ribs. The anastomosis is done in two layers using interrupted suture and the inner layer apposes mucous membrane to mucous membrane. The stomach is then telescoped over the suture line and the diaphragm is repaired and sutured about the stomach. The utilization of a thoracoabdominal incision has been followed by fewer postoperative complications. The abdomen is opened first through a left rectus incision, and then carried upward and laterally through the costal margin to the eighth left interspace, cutting the diaphragm. The resulting exposure simplifies satisfactory block dissection. In closing, the wound is repaired in layers. Jejunostomy is done routinely, for postoperative feeding. The chest is drained. In total gastrectomy, intestinal continuity is reestablished by suturing the esophagus to the jejunum, and using the Y anastomosis of Roux. The jejunal segment is brought up through the mesocolon. The Y jejunal anastomosis is

preferable to the ordinary jejunal loop. No gastric stump should be left behind, since it may produce pylorospasm. After operation, the patient is placed in an oxygen tent, penicillin is administered, trapped air within the chest is aspirated, and the patient is fed through the jejunostomy. He is given nothing by mouth until the fourth day, but is usually back on a full diet by the third week. In the discussion, there was unanimous praise for the exposure effected by the thoracoabdominal incision. When contemplating total gastrectomy, the initial abdominal incision solves the question of operability before opening the chest.

**Section of the Vagus Nerves to the Stomach in the Treatment of Peptic Ulcer, Lester R. Dragstedt,** Chicago.—Section of the vagus nerves has been done in eighty-two patients over a period of the last three and a half years. Thirty of these patients had abdominal vagectomies, and the remaining fifty-two were operated on transthoracically. The lower four inches of the esophagus must be completely denervated and the proximal cut ends of the vagi should be covered with pleura to prevent regeneration. In this series there has been no evidence of regeneration and at least twelve of these patients were operated on more than three years ago. When the abdominal subdiaphragmatic approach is employed, the esophagus is mobilized by finger dissection and pulled down about three inches. The rationale of the operation is based on the fact that increased activity or hypertonus of the vagus efferent fibers should augment gastric motility and the secretion of gastric juice. In ulcer patients, the excessive continuous secretion of gastric juice occurs in the stomach in the absence of the usual stimulus of food. Complete section of the vagus nerves abolishes hypermotility and hypersecretion, the ulcer heals, and pain disappears. Evidence was presented showing that vagal section reduces gastric secretion fifty per cent and the secretion of the free hydrochloric acid component, seventy-five per cent. The fact that the stomach when empty may secrete large amounts of gastric juice, and that interruption of the vagus nerves reduces this secretion, indicates that the cortex has an important role in the hypermotility and hypersecretion of ulcer patients which is mediated through the vagus nerves. These findings support the concept of ulcer as a psychosomatic disease. Pain ceases and ulcers heal when the corticogastric connection is broken. Vagal section does not anesthetize the stomach since the reintroduction of hydrochloric acid will produce pain. The sense of hunger remains unchanged. The lack of response to the stimulation of a sham meal or insulin hypoglycemia after operation indicates that no regeneration of the vagal secretory fibers has occurred. Gastric tonus and motility is reduced but not abolished; intestinal motility is not decreased. The stomach is kept decompressed for three or four days after operation to avoid acute gastric dilatation. There may be a transient diarrhea for two or three weeks. X-ray and gastroscopy afford objective evidence that gastric, duodenal, and marginal ulcers heal after vagal section. It is possible that three and a half years is too short a time to permit evaluation of final results and to determine whether vagus nerve regeneration can occur after that interval. The transthoracic approach may be used for duodenal ulcers without pyloric obstruction, and for marginal ulcers. The abdominal approach is suggested for gastric ulcers to exclude malignancy, and for duodenal ulcers with cicatricial pyloric stenosis, so that gastroenterostomy may be done. In discussing this paper, **Dr. D. T. Smith** pointed out that vagal section in ulcer patients not only stops pain but eliminates bleeding. **Dr. Frank Berry** advised that the patient should be cautioned not to overeat, since long-continued tonus of the pylorus may persist.

**The Management of Thoracic Surgery in the Hospitals of the Veterans Administration, Brian B. Blades,** Washington, D. C.—This was a brief description of the new organization, pointing out that management has been decentralized and that the veterans hospitals so far as possible will be connected with medical schools and will be used for teaching. There should be a plethora of clinical material. Pay scales have been raised and certification by one of the American boards carries an additional 25 per cent wage increase. Under this plan, which lifts the organization out of Civil Service, there should be freedom from administrative duties and red tape.

**Presidential Address: The Direct Approach to Cardiovascular Disease, Claude S. Beck, Cleveland.**—Although the incidence of cardiovascular disease exceeds all others, the

funds available for the study and treatment of individuals suffering from this group of ailments are most meager when judged by the ratio of the number of such patients to the amount of money available. The relative and actual poverty in this field stands out in sharp contrast to the funds which have been collected for the investigation and treatment of cancer and infantile paralysis. The internist has used indirect methods of study and investigation in this field. However, direct visualization of the heart and blood vessels is now possible and will yield precise knowledge. The program of this meeting displays examples of the results of the direct approach to cardiovascular disease, and includes such subjects as foreign bodies in the heart, the suture of wounds of the auricles and ventricles, the surgical treatment of patent ductus arteriosus, coarctation of the aorta, and the Tetralogy of Fallot. This direct mode of treatment has been applied in contusions of the heart, which are probably more common than penetrating wounds of the heart, and also to the immediate and late repair of peripheral vascular injuries. It has proved useful in extrinsic lesions of the heart where the heart is hindered by fluid, adhesions or scar tissue, and in compression of the heart. The concept of acute and chronic compression of the heart, and torsion and rotation simplifies diagnosis and treatment. Surgery for portal hypertension is another result of the direct approach, as well as orderly procedures for resuscitation, the prevention of pulmonary emboli, and sympathectomy for hypertension and causalgia. The problem of coronary sclerosis has been attacked. Ligation of a main coronary will produce ventricular fibrillation by destroying the coordinating nerve network, but this can be obviated by the supply of a small additional amount of blood to the myocardium either by a graft or the production of intercoronary channels as a result of abrading the surface of the heart or the use of powdered asbestos in the pericardium. In experimental animals, coronary ligation is fatal in 70 per cent, but where the heart has been abraded only 38 per cent die. With survival of an attack of coronary occlusion, new intercoronary channels develop. It is possible that coronary sinus ligation might help. Operations to augment a deficient coronary circulation have been done on 37 patients. Neurectomy about the base of the aorta or the large coronary vessels might improve the cardiac circulation. The further use of the direct approach may well lead to the transplantation of arteries, the temporary exclusion of the heart from the circulation, permitting the closure of septal defects or the removal of vegetations, tumors, or thrombi from valves.

**The Tetralogy of Fallot: Diagnosis and Indications for Operation, Helen B. Taussig,** Baltimore, and **The Surgical Treatment of the Tetralogy of Fallot, Alfred Blalock,** Baltimore.—The tetralogy of Fallot consists of pulmonary stenosis, interventricular septal defects, dextroposition of the aorta so that it receives blood from the right ventricle as well as left ventricle, and right ventricular hypertrophy. The usual clinical picture is one of marked cyanosis, normal sized heart, systolic thrill, and right axis deviation. These patients can be helped if it is possible to increase the flow of blood to the lung and thereby augment the arterial oxygen saturation. The operation helps only where there is some impediment to the pulmonary circulation. In the event of congenital absence of the pulmonary artery, operation is impossible. The heart should be normal in size to enable it to assume the additional circulation. Avoid cases where the heart presents an enlarged pulmonary conus. The pressure in the pulmonary artery must be lower than the pressure in the systemic arterial circulation, to permit the new shunt to function. Twenty per cent of these little patients have a right-sided aortic arch. It is important to recognize this before operation which is done on the side opposite the aortic arch. With dextroposition of the aorta, x-rays are valuable, especially the anteroposterior projection, and they show the esophagus lying close to the heart and displaced to the left and forward. The age of 5 to 6 years is preferred, but the operation may be done in younger patients depending upon the degree of incapacity and the elevation of the red blood count. Without operation, the chance of survival to puberty is only 50 per cent. With an arterial oxygen saturation as low as 30 per cent, an afflicted child can hardly walk. These children exhibit varying degrees of polycythemia which seems to be compensatory. Cerebral thrombosis frequently complicates the picture when the erythrocyte count reaches eight or nine million (or an hematocrit of 70 to 80). Maintenance of an adequate fluid intake lessens the risk of cerebral thrombosis. Venesection is frequently done at the end of operation

to reduce the load on the pulmonary circuit. **Dr. Blalock** demonstrated the operation with a splendid motion picture which showed the incision through the third interspace anteriorly, ligation of the azygos veins, and measurement of the pulmonary arterial pressure. The average pressure was between 190 and 200 mm. of water; when the pressure is 300 or over, operation is impossible. The operation is easier on the left side, with a right aortic arch. The shunt has been made utilizing the innominate, the common carotid, and subclavian artery. Those anastomoses in which the subclavian artery was used have had the lowest mortality. The right superior pulmonary artery may be mistaken for the main pulmonary artery. The selected systemic artery is divided and its distal end ligated while the proximal segment is occluded with a bulldog. The pulmonary arterial segment, into which the systemic artery selected is to be anastomosed end-to-side, is occluded gently but securely between soft blood vessel clamps. The anastomosis is done with an everting suture, intima to intima, using 00000 Deknatel silk. Small leaks in the suture line are stopped by finger pressure or an interrupted suture. The mediastinal pleura is then closed. Should the wrong side be chosen for the incision, one may still find suitable vessels for the anastomosis. One hundred forty-four cases have been operated on and 118 anastomoses have been done with eighteen deaths (22 per cent mortality). The patients ranged in age from 2 months to 26 years. The innominate artery was used in thirty-six cases with twelve deaths; the subclavian artery in seventy-two cases with six deaths. It was strongly urged that no one, no matter how greatly skilled, should try this operation on a human without first carrying out the procedure on at least two dogs.

**The Surgical Treatment of Coarctation of the Aorta, Clarence Crafoord,** Stockholm, Sweden.—**Dr. Crafoord** spoke as he showed a fine moving picture of this operation, which he first performed in October, 1944. For anesthesia, local is used with the endotracheal administration of cyclopropane, oxygen, and nitrous oxide. The intratracheal gas pressure is kept below 25 mm. of water. The approach is through a long S-shaped posterolateral incision, exposing an entire rib. A heavy transfixion suture is used to elevate the scapula. The phrenic and vagus nerves are injected with novocain. Two or three pairs of collateral arteries arising from the aorta proximal to the contracted portion, are divided and ligated. The zone of coarctation is excised between clamps and continuity is restored by suture, using 00 oiled silk, each bite being 2 mm. back from the cut edge. The suture does not penetrate the lumen or evert the edges of the aorta. The blood given during the operation is taken from a heparinized donor (1 mg. heparin per kilo body weight). The wound is closed by running sutures in the pleura, periosteal rib bed, and muscles of the chest wall. In discussing this paper, **Dr. Robert E. Gross** told of his experimental work to determine the practicability of bringing the cut ends of the aorta together. He anastomoses the aorta with 00000 silk using a continuous mattress suture which everts the cut edges. The posterior portion of the aortic suture line is placed first. He divides the necessary intercostal arteries to effect mobilization of the aorta and divides the ligamentum arteriosus. He reported eight cases with two deaths and five good results, and added that some of the benefits may come rather slowly. He urged that the clamps be removed from the aorta gradually to minimize what may be a sudden strain on the heart. In closing, **Dr. Crafoord** said that he removed the aortic clamps quickly and had not seen any harmful results.

**Complications of the Surgery of Patent Ductus Arteriosus, John Jones,** Los Angeles.—Although there have been no wound infections, the frequency of keloid formation in the scars of the anterior incisions caused its abandonment and the substitution of the posterolateral incision, with the section of the fourth and fifth ribs. The occurrence of an aortobronchial fistula was described, in which the patient had six recurring hemoptyses over a period of twenty-one months. On exploration, a knuckle of lung was found adherent to the aorta and when the lung was dissected away from the mediastinum, the knots of umbilical tape were recovered which had eroded into both the lung and aorta. On removal of these knots, the rent in the aorta was closed by suture, with recovery. Routine closure of the mediastinal pleura should eliminate this complication. In the fifty-three cases where ligation was done, murmurs persisted in five patients and in five more, murmurs reappeared. The persistence or recurrence of the murmur indicates the re-establishment of the fistula. In the eight patients in which

complete division of the ductus was carried out, there has been no recurrence of the murmur. There were two deaths in this series of sixty-one cases. One occurred in a patient whose condition was complicated by a staphylococcus endarteritis where the fistula recurred, with the formation of an aneurysm. The other case was one of rheumatic heart disease with a rigid ductus, death following a leak in the pulmonary artery.

**Complete Division of the Patent Ductus Arteriosus, Robert E. Gross,** Boston.—In a series of 133 cases of surgically treated patent ductus arteriosus, some form of ligation was employed in forty-three instances. Of the forty survivors, there were thirty-two perfect results, four in which the murmur persisted from failure to ligate tightly enough to obliterate the shunt, and four in which the murmur recurred probably because the ligature cut part way through, with re-establishment of the fistula. These failures led to the development of a technique of complete division of the ductus which has now been carried out in ninety cases. The approach is through an anterior incision below the left breast, with section of the second and third costal cartilages and incision of the third interspace. A tongue of pericardium is dissected up and the posterior wall of the ductus freed first. The ductus is clamped doubly at both extremities and after division, the pulmonary arterial end is closed first. The distal clamp is removed and closure is effected by an over-and-over suture of fine silk, which is returned as a second suture to its starting point. After a similar closure of the aortic end of the fistula, the mediastinal pleura is closed. There were two deaths in this latter series, one from mediastinitis and one from cardiac dilatation. In a child, the patent ductus is soft and pliable and easy to ligate, and any technique should be effective, while in an adult the ductus is often stiff and inelastic, thereby increasing the chance of failure of ligation. Complete division is definitely better because it is just as safe as ligation and more satisfactory in permanently closing these shunts. The discussion was opened by **Dr. Crafoord,** who told how it took him two and one-half years to sell this operation to the pediatricians in Stockholm. He reported seventy-one cases of patent ductus which he had treated surgically, about one-half by double ligation with the injection of 50 per cent glucose solution between the ligatures, and the other half, usually those with short ducts, by division. In an early case where complete division was being done, the clamp, including the stump, was torn from the aorta. To control hemorrhage, the aorta was clamped above and below the tear, which was closed by suture. This procedure so facilitated the operation, that he now treats the aortic end of the ductus routinely in this manner. This series includes seven infected cases with positive blood cultures. He uses a posterolateral incision between the fourth and fifth ribs, and interposes a pericardial flap at the site of the division. There were two deaths in this series. **Dr. Wangensteen** said that he deliberately opened the pericardium and developed the tissue plane, separating fibrous and serous pericardium if these layers were not otherwise readily separated. He divides the ductus routinely, a procedure which he has carried out successfully in thirty-three consecutive patients. **Dr. A. S. W. Touroff,** who in 1940 first reported the successful ligation of a patent ductus in subacute bacterial endocarditis, reported thirteen cases, with eight regarded as cured (well from four to six and one-half years), two operative deaths, and three unimproved. He said that existence of a murmur was not evidence of recanalization, since it could occur even after division, and that it probably was caused by the dilated pulmonary artery. Recanalization was probably due to failure to pull down tightly enough on the knots. Tight ligatures should not cut through, but knots may become loose in the presence of infection. **Dr. Edgar Davis** told of a case where the murmur was reduced about 50 per cent after ligation; he reoperated and placed two more ligatures on top of the preceding ones, but the murmur persisted. Fascia or fibrin foam should be interposed between the divided ends of the ductus.

**Decortication for Tuberculous Empyema, Fraser B. Gurd,** Montreal.—As a result of a large experience with cases of chronic empyema, decortication had been found frequently to be successful in producing re-expansion of a lung, even after the lung had been compressed for long periods of time. Since the conventional treatment for tuberculous empyema had proved relatively unsatisfactory and left the patient with a permanent reduction in respiratory function, decortication was tried in three cases. Adequate exposure is obtained in these stiffened

chest walls by thoracotomy, done in stages. It is sometimes difficult to find the proper plane of cleavage for dissection. Not only must the fibrous membrane be removed from the surface of the lung but the dissection must be carried to the hilar region if maximum re-expansion is to be obtained.

**Lobectomy and Pneumonectomy in the Treatment of Pulmonary Tuberculosis, Richard H. Sweet,** Boston.—In 1943, Drs. Churchill and Klopstock reported six cases of pulmonary tuberculosis treated by lobectomy with two poor results (one now dead) and four good ones. This present series consists of fifty-seven additional cases of extirpation done prior to June, 1945. To simplify the evaluation of the procedure and reduce variables, thoracoplasty has not been done after any of these pulmonary resections. Indications for lobectomy were: (1) unfavorable location of cavity, (2) tuberculoma, (3) rigid cavity, and (4) bronchial stenosis. The indications for pneumonectomy were: (1) "destroyed lung," (2) thoracoplasty failure, (3) bronchial stenosis, and (4) technical reasons. These patients were bronchoscoped routinely before and after operation. Chemotherapy reduced or eliminated suppuration. Ether and oxygen were administered through an intratracheal tube; patients were placed on their side. Silk technique was used throughout, and the bronchial stump was always covered with pleura. It was essential that the hilum be free of disease. Dissection of the periphery of the lung was sometimes very difficult. Frequently diseased areas can be seen or felt, where they were not suspected on the basis of previous x-ray examination. The chief complications, namely flare-ups and empyema, occurred with approximately the same frequency after lobectomy and pneumonectomy; there were thirteen flare-ups in twenty-seven lobectomies and ten after pneumonectomy. There were two postoperative deaths in the series of twenty-seven lobectomies; of the twenty-five survivors, five have since died of tuberculosis, seven are alive with tuberculosis, and thirteen appear to be well. In the eleven so-called "elective" cases, seven are well and the other four are living but are still sick. In the tension cavity group of nine cases, there was one postoperative death, four died later, one is living but still sick, and three are well. The two cases of bronchial stenosis resulted in one death and one survivor who still has tuberculosis. There were thirty-six pneumonectomies with seven postoperative deaths; of the twenty-nine survivors, seven have since died of tuberculosis, five are still sick, and seventeen are well. Out of eighteen who were operated on for "destroyed lung," three are well; of six whose indication was bronchial stenosis, five are well. In five cases where pneumonectomy was done for technical reasons, four are well; in four cases of thoracoplasty failure, three are well. There were two cases of erroneous diagnosis; both proved to be cancer, and they are well. Frequently widespread dissemination of tuberculosis in both lungs was noted in the absence of x-ray evidence. There is no way to evaluate the relative toxicity of the tuberculous process and compare it objectively with the resistance of the patient. It appears to be impossible to eradicate the entire disease. This fact and the paramount importance of the individual's resistance suggest that in a broad sense, tuberculosis should not be considered amenable to surgery.

**Further Experiences in Pulmonary Resection in the Treatment of Pulmonary Tuberculosis, Richard H. Overholt,** Boston.—This report dealt with the experience in 200 resections (192 patients), performed since 1934. The first ninety-three were done before April, 1944, and the patients received general anesthesia and were placed in the conventional side position. The remainder, done since April, 1944, were done under local anesthesia and placed face down on the operating table. The objective has been to eliminate or at least minimize the occurrence of bronchopleural fistulas, empyema, and spreads. Fistulas are now quite rare. The patient is positioned on the table face down, to prevent the flow of secretions into the contralateral lung. Local anesthesia is used, infiltrating the skin and the intercostal nerves. In the face down position, the patient breathes better, has a higher vital capacity than when lying on his side, and tolerates an open pneumothorax without positive pressure. An endotracheal tube is used routinely for aspiration. This series consisted of twenty resections for bronchial tuberculosis, thirty-two for thoracoplasty failure, ninety-four for extensive unilateral disease, twenty-eight for extensive upper lobe disease, eighteen for basal disease, six for tuberculoma and two for giant cavities. Of these, 142 were previous treatment failures. The best results

were obtained in stabilized cases. The complications of lobectomy were fistula, empyema, wound infection, and spreads, both contralateral and ipsilateral, the latter being somewhat higher. There were more empyema and wound infections after pneumonectomy but fewer contralateral spreads. Late and delayed complications were less frequent after pneumonectomy than after lobectomy. Out of 127 pneumonectomies, forty-six were done on the right and eighty-one on the left side. Apical thoracoplasty accompanying an upper lobe resection reduces the likelihood of spread. It is important not to overstretch the remaining lung.

**Dr. John Streider** opened the discussion and said that the indications for lung resection in tuberculosis have not changed, and reported ten lobectomies (one operative death) for tuberculoma and apical cavity and thirteen pneumonectomies (two operative deaths) for basal cavities, extensive diseases, and thoracoplasty failures. Evidence of spread was noted after 60 per cent of the lobectomies and 45 per cent of the pneumonectomies. Resection does not appear to be the answer. **Dr. E. J. O'Brien** said that tuberculosis is an unpredictable and recurrent disease, and that it cannot be eradicated in toto surgically. Pneumonectomy is preferable to lobectomy insofar as it excises more of the disease. He emphasized that other forms of therapy have been successful, viz, thoracoplasty gives better results in extensive unilateral disease, and basal lesions are more often cured by measures other than resection. He thought that the face down position was excellent but stated that spreads do not result from the position on the table but from coughing. In combating tuberculosis, anything which augments the patient's immunity to the disease is important. One cannot operate on a constitutional disease, locally. **Dr. Baily,** reporting eighty cases of pulmonary resection, said that his mortality was higher for pneumonectomy than lobectomy and that the incidence of spreads was proportional to the amount of sputum. Since complete aspiraiton of the bronchial tree is not possible, he urged the use of the Trendelenburg position to minimize spilling into the better lung. **Dr. J. R. Head** stated that in acute bronchial obstructions, which start early in the disease and are characterized by wheezing and difficult coughing, lobectomy was indicated, but that in all chronic bronchial obstructions thoracoplasty was effective. He added that he felt that 90 per cent of these resections were unnecessary; some other forms of therapy would have been more effective and safer. **Dr. Sweet** said, in closing, that he thought the results of resection had been better than he thought they would be. **Dr. Overholt** said with some emphasis, that he did not recommend resection generally; in fact, he rejected two out of three cases presented for resection. His aim is to salvage cases which appear to be hopeless with usual means of therapy. He restricts resections to those who have no apparent chance of recovery by any other means.

**Cavernostomy, F. C. Test,** Detroit.—This procedure consists of rib resection and drainage of a tuberculous cavity, which is entered with a cautery. The operation, which was described as "very messy," arrests rather than cures the underlying lesion. It is employed when other surgical procedures are not applicable. It is restricted to bad risks. This series covers seventy-four patients and eighty operations. They fall into three categories: (1) solitary large cavity without acute or progressive exudative disease, in patients with too limited a cardiorespiratory reserve to permit collapse therapy, (2) large, solitary cavity with minimal surrounding infiltration, located in the lower lobe, without active disease of the upper lobe, and (3) residual cavity beneath an optimal thoracoplasty collapse, in the absence of acute progressive exudative disease. As might be expected in such a group of salvage cases, morbidity and mortality were high, but the results in the second and third groups were sufficiently encouraging to warrant further use of cavernostomy in certain tuberculosis patients unsuited for other surgical procedures. The cavity is opened with a cautery and then packed; the wounds show a remarkable tendency to heal. There is sputum conversion in 78 per cent of the cases. Death is due to progression of the underlying lesion. The best results are in lower lobe cavities, where 83 per cent are arrested; in the postthoracoplasty group, 55 per cent were arrested. The worst results occurred where dyspnea was the outstanding symptom. **Dr. W. A. Hudson** pointed out the limitations of the operation but said that it tended to make the patient more comfortable and prolonged life. He advised that cavity drainage (Monaldi technique) be done first, and then cavernostomy, with use of a skin flap. **Dr. W. L. Rogers** also

endorsed the operation, especially for use in cavities in the upper portion of the lower lobe. He advised that it be done in stages and that the first step should be the preparation of a skin flap, which is later to be dropped into the cavity; packing the cavity is unnecessary.

**Surgical Removal of Foreign Bodies From the Heart, Dwight E. Harken,** Boston.—This was a remarkable moving picture of three cases, showing the detailed technique of removing foreign bodies from the chambers of the heart. There were no deaths in a series of 134 operations for foreign bodies in the heart or pericardium. In one instance, it was only at the third attempt, and this at the request of the patient, that the foreign body was recovered from the right ventricle. More foreign bodies were left in situ than were removed. The question of removal often depends on the emotional reaction of the patient, who "harbors an unwelcome visitor in the citadel of his well-being" (Grey Turner). The rationale of the removal of foreign bodies is based on the prevention of bacterial endocarditis (67 per cent of foreign bodies were infected), emboli, pericardial effusion, rupture or herniation of the heart, pain, and cardiac neurosis. Localization of foreign bodies in the right ventricle by x-ray and fluoroscopy show them to lie anteriorly and apparently on the diaphragm. One-third of the foreign bodies thought to be within the heart, were found to be elsewhere. Adequate exposure is essential. The bony cage of the chest is preserved by use of an incision through an intercostal space and division of costal cartilages, which are sutured when the chest is closed. A transpleural approach is used because it expedites the operation and improves the exposure. It is very important that the heart should be dislocated as little as possible from the position of maximum function. The heart, once exposed, should be kept moist and bathed in a novocain solution. Transfixion sutures are placed on either side of the proposed incision through the wall of the heart. After incision of the heart and removal of the foreign body with an hemostat, these sutures are crossed, until closure is effected with interrupted sutures, and this suture line is reinforced with a pericardial graft. The actual removal takes 15 to 25 seconds. The patient receives pressure transfusions during the operation to replace the blood loss which may amount to as much as a liter. In the discussion, the value of pressure transfusion and the transfixion sutures was emphasized. **Dr. Decker** pointed out that the length of survival was about the same whether the foreign body was removed or left behind, but that in many individuals, awareness of a foreign body in or around the heart produced marked emotional disturbances. **Dr. P. C. Samson** spoke of the safety of removal of these foreign bodies and the responsibility of determining whether they should be removed or left behind. **Dr. Brodkin** told of a wounded soldier, exhibiting the signs of cardiac compression, who, when explored and when a thickened pericardial membrane was excised, was found to be harboring his dog tag in the pericardium. **Dr. Miscal** said that a foreign body left within the heart could produce symptoms of coronary thrombosis. He reported the removal of foreign bodies lying within the pulmonary artery, bronchi, and superior vena cava in thirty-nine cases without any deaths. **Dr. J. R. Head** told of two cases of foreign body in the lung where the only symptom was hemorrhage; the surgical removal effected a cure. **Dr. Claude Beck** suggested that with intramural foreign bodies, mattress sutures be used to exteriorize them.

**Cardiac Resuscitation, Mercier Fauteux,** Boston.—The usual methods of cardiac resuscitation (e.g., massage, adrenalin, electrical shocks) employed after cardiac arrest (standstill) or primary ventricular fibrillation secondary to various causes, have not always been successful in reviewing cardiac function after a brief period of complete stoppage of the circulation. After a very few minutes of standstill or ventricular fibrillation, the heart cannot be started again. The cause of failure of resuscitation may be (1) hyperirritability of the heart, (2) absence of cardiac tone, (3) elevation of the myocardial temperature, or (4) peripheral circulatory failure. The value of novocain, barium chloride, cold solutions, and the intracardiac perfusions of glucose, Ringer's solution, and blood to control the causes of failure were investigated. These measures when properly employed and in conjunction with the usual methods, namely, artificial respiration, massage of the heart, and intracardiac injection of adrenalin, lessen considerably the incidence of failure. The first step in resuscitation should be to stop the ventricular fibrillation. In failure, hyperirritability may be augmented rather than lessened by too much massage or the too liberal use of adrenalin. The use of cold solu-

tions may be helpful by reducing myocardial temperature. Peripheral circulatory failure, a concomitant of cardiac standstill, is best combated by directly perfusing the heart. In the discussion, **Dr. Claude Beck** pointed out that, in evaluating experimental findings, a cat's heart will stop fibrillating spontaneously, while a dog's heart will not. He advocated the use of novocain and electric shock for resuscitation of the heart and said that this process was reversible until brain damage has been done. **Dr. O. C. Brantigan** and **Dr. C. Crafoord** told of cases of prolonged cardiac arrest in patients who were resuscitated by the use of novocain, massage, and adrenalin. Dr. Fauteux pointed out that not only cyclopropane but any anesthetic induction, when combined with the use of adrenalin, might throw the heart into fibrillation.

**Traumatic, Diaphragmatic Hernia. Earle B. Kay,** Memphis, Tenn.—Twenty-eight cases of traumatic hernias were reported; five were on the right side and twenty-three on the left side. Seventeen of them were the result of perforating wounds and eleven, the result of contusions. Symptoms of acute obstruction developed in two cases while under observation, and resection of the colon was necessary in one patient, admitted with evidence of obstruction. These hernias were all repaired through a transpleural approach, which gave excellent exposure of both the abdominal and thoracic organs. The eighth or ninth rib was resected, and the phrenic nerve was crushed routinely. In only two of these hernias, were sacs present. The diaphragm was repaired with tantalum wire and the chest was closed without drainage except in the one instance which required resection of the bowel. Since there were many diaphragmatic injuries in the war, it seems probable that this condition will be seen more frequently in the future.

**Thoracogastric Fistula Caused by Surgical Mistreatment of Herniated Stomach, G. E. Lindskog,** New Haven, Conn.—Two cases were presented in which a herniated intrathoracic stomach had been inadvertently drained surgically (by other surgeons) under the misapprehension that a left pyothorax was the underlying condition. The first case developed a chronic peptic ulcer at the site of the previous catheter drainage, with erosion of the overlying rib and repeated hemorrhages from the intercostal artery. The treatment consisted of partial gastric resection, reduction of the herniated viscera, and repair of the diaphragm. In this case, the sac was adherent to the chest wall, and there was no pneumothorax or empyema. The second case presented a massive pyopneumothorax and gastric fistula, subsequent to a similar error in diagnosis. It was treated by thoracotomy for drainage, jejunostomy for feeding, and later reduction and repair of the herniated stomach. In both cases, definite history of previous chest trauma should have afforded an adequate clue to proper diagnosis and treatment. In view of the large number of men with chest wounds returning from the war to civilian life, attention should be called to the possibilities of incorrect diagnosis which might be made by the unwary, as well as to methods of handling complications following ill-advised surgical intervention.

**Congenital Eventration of the Diaphragm: Surgical Management; Case Report, Dewey Bisgard,** Omaha.—Congenital eventration of the diaphragm is a rare condition; only 183 cases have been reported, for all ages. It is not a hernia but an abnormally high position of one leaf of the diaphragm, which may be paralyzed. They occur more frequently on the left side. It is rarely recognized and probably mistaken in some instances for other lesions which cause dyspnea and cyanosis in infants. The case was that of a 6-week-old male baby, who was increasingly dyspneic and cyanotic from birth until at the time of operation; survival was possible only in an oxygen chamber. The eventration, which was right-sided, was approached through the ninth interspace, and the diaphragm was found at the level of the second rib. Motion of the diaphragm appeared to be normal. The diaphragm was restored to its normal position by pleating and plication. The infant has remained well and developed normally up to the present, eighteen months after operation.

# Book Reviews

**Extensile Exposure Applied to Limb Surgery.** By Arnold L. Henry, M.B., Dublin; M. Ch. (Hon.), Cairo; F.R.C.S.I. Baltimore, 1945, Williams & Wilkins Company. $7.

This book is an improvement over a similar book by the same author entitled *Exposure of Long Bones and Other Surgical Methods* published in 1929. As a surgical guide to selected areas of the extremities, it has no peers. Henry has described the exposures to those regions with which surgeons have had the greatest difficulty and the most complications. One can but wonder at the broad surgical experiences and knowledge of anatomy which the author must possess. Not only is this book an excellent surgical text but it is also good literature.

In many instances it is necessary to exposure not only bone but also nerves and blood vessels. The part of the title, *Extensile Exposures,* is well selected for the exposures described can be extended to include surgically important structures. Thus, each exposure may be likened to a main highway with many branching roads. The main highway is taken until the road leading to a particular destination is reached.

The anterolateral exposure of the humerus with its extension to include the contents of the axilla and neck is beautifully described. A posterior approach to the humeral shaft, to the radial nerve, and to the neurovascular bundle in the arm is demonstrated. Although this exposure is good for the humeral shaft, it is rather deep to the nerve and vessels and necessitates the splitting of muscle. The anterior approach to the radial shaft is one which is not used often enough. It is particularly adaptable to the upper third of the radial shaft, a region where surgical complications are frequent. The entire radius is available through this incision from the elbow to the wrist. The author's posterior approach to the structures in the buttocks is worthy of mention, for it avoids splitting the gluteus maximus as in some other approaches to this area. The sciatic nerve, the posterior portion of the acetabulum, and the posterior aspect of the neck of the femur may be exposed. The almost general applicability of the anterolateral incision to the shaft of the femur is widely accepted.

Many other approaches are described and these include back of the forearm, the hand, the knee and popliteal fossa, the back of the thigh and leg, the fibula and the perineal nerves, the sole of the foot, and others. Description of all these exposures includes a detailed analysis of the anatomy and relations of the structures involved. Many other important details of surgical technique are given. These include pitfalls, the location of landmarks, the placement of incisions, the position of the patient on the operating table, and little practical tricks to find certain structures and to avoid others.

Everyone interested in surgery of the extremities could learn much of importance from this book.

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## Books Received

The receipt of books is acknowledged in this section and this treatment must be regarded as sufficient acknowledgment of the courtesy of the senders. Selections will be made for more extensive review dictated by the interests of our readers and as space permits.

A HISTORY OF MEDICINE. By Douglas Guthrie, M.D., F.R.C.S. Cloth. Pp. 447, with 72 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

THE SURGICAL TECHNIC OF ABDOMINAL OPERATIONS. By Julius L. Spivack, M.D., LL.D., Associate Professor of Surgery, University of Illinois. Cloth. Price $10. Pp. 671, with 682 illustrations. Springfield, Ill., 1946, Charles C Thomas, Publisher.

A TEXTBOOK OF GYNECOLOGY. By Arthur Hale Curtis, M.D., Professor of Obstetrics and Gynecology, Northwestern University Medical School. Cloth. Price $8. Pp. 755, with 455 illustrations. Philadelphia, 1946, W. B. Saunders Company.

AUTOPSY, DIAGNOSIS AND TECHNIQUE. By Otto Saphir, M.D., Pathologist, Michael Reese Hospital and Professor of Pathology, University of Illinois Medical School. Foreword by Ludvig Hektoen, M.D. Cloth. Pp. 375, with 69 illustrations. New York, 1946, Paul B. Hoeber, Inc.

WOMEN IN INDUSTRY—THEIR HEALTH AND EFFICIENCY. By Anna M. Baetjer, Sc.D., Assistant Professor of Physiological Hygiene, School of Hygiene and Public Health, The Johns Hopkins University. Cloth. Price $4. Pp. 325, with 33 illustrations. Philadelphia, 1946, W. B. Saunders Company.

DEMONSTRATION OF OPERATIVE SURGERY FOR NURSES. By Hamilton Bailey, F.R.C.S., Surgeon, Royal Northern Hospital, London. Cloth. Price $5.50. Pp. 337, with 530 illustrations. Baltimore, 1945, Williams & Wilkins Company.

MEDICAL SERVICES BY GOVERNMENT. By Bernhard J. Stern, Ph.D., Lecturer in Sociology, Columbia University. Cloth. Price $1.50. Pp. 189, with no illustrations. New York, 1946, Commonwealth Fund.

HUMAN TORULOSIS. By Leonard B. Cox, M.D., M.R.C.P., F.R.A.C.P., Lecturer in Neuropathology, Stewart Lecturer in Medicine, University of Melbourne, and Jean C. Tolhurst, M.Sc., Senior Bacteriologist to the Alfred Hospital, Melbourne. Cloth. Price $2.50. Pp. 137, with 67 illustrations. Melbourne, 1946, Melbourne University Press.

PERIPHERAL VASCULAR DISEASES. By Edgar V. Allen, M.D., Division of Medicine, Mayo Clinic; Nelson W. Barker, M.D., Division of Medicine, Mayo Clinic; and Edgar A. Hines, Jr., M.D., Division of Medicine, Mayo Clinic. Cloth. Price $10. Pp. 871, with 386 illustrations. Philadelphia, 1946, W. B. Saunders Company.

ANESTHESIA IN GENERAL PRACTICE. By Stuart C. Cullen, M.D., Head of the Division of Anesthesiology of the Department of Surgery, State University of Iowa Hospitals, Associate Professor of Surgery, State University of Iowa College of Medicine. Cloth. Price $3.50. Pp. 252, with 36 illustrations. Chicago, 1946, The Year Book Publishers, Inc.

MEDICAL EDUCATION AND THE CHANGING ORDER. By Raymond B. Allen, M.D., Ph.D., Executive Dean, Colleges of Dentistry, Medicine and Pharmacy, University of Illinois. Cloth. Price $1.50. Pp. 136, with no illustrations. New York, 1946, Commonwealth Fund.

NEW ASPECTS OF JOHN AND WILLIAM HUNTER. By Jane M. Oppenheimer, Bryn Mawr College. Cloth. Price $6. Pp. 188, with 3 illustrations. New York, 1946, Schuman's.

THE NORMAL ENCEPHALOGRAM. By Leo M. Davidoff, M.D., Professor of Clinical Neurological Surgery, Columbia University, and Cornelius G. Dyke, M.D., Late Associate Professor of Radiology, Columbia University. Cloth. Price $5.50. Pp. 241, with 155 illustrations. Philadelphia, 1946, Lea & Febiger.

THE PRINCIPLES OF NEUROLOGICAL SURGERY. By Loyal Davis, M.S., M.D., Ph.D., D.Sc., Professor of Surgery and Chairman of the Division of Surgery, Northwestern University Medical School. Cloth. Price $7.50. Pp. 532, with 348 illustrations. Philadelphia, 1946, Lea & Febiger.

PENICILLIN, ITS PRACTICAL APPLICATION. By Professor Sir Alexander Fleming, M.B., B.S., F.R.C.P., F.R.C.S., F.R.S., Professor of Bacteriology in the University of London, St. Mary's Hospital, London. Cloth. Price $7. Pp. 359, with 59 illustrations. Philadelphia, 1946, The Blakiston Company.

EARLY AMBULATION AND RELATED PROCEDURES IN SURGICAL MANAGEMENT. By Daniel J. Leithauser, M.D., R.A.C.S., Chief of Surgery, St. Joseph's Mercy

Hospital, Detroit. Cloth. Price $4.50. Pp. 232, with no illustrations. Springfield, Ill., 1946, Charles C Thomas, Publisher.

TREATMENT OF BRONCHIAL ASTHMA. By Vincent J. Derbes, M.D., Director of the Department of Allergy, Ochsner Clinic, New Orleans, and Hugo T. Engelhardt, M.D., F.A.C.P., Instructor of Clinical Medicine, Baylor University College of Medicine, Houston. Cloth. Price $8. Pp. 445, with 61 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

RENAL HYPERTENSION. By Eduardo Brown-Menendez, Juan Carlos Fasciolo, Luis F. Leloir, Juan M. Munoz, and Alberto C. Taquini. Institute of Physiology, Faculty of Medical Sciences and Institute of Cardiology, V. F. Grego Foundation, Buenos Aires, Argentina. Translated by Lewis Dexter, M.D., Harvard Medical School. Cloth. Price $6.75. Pp. 450, with 93 illustrations. Springfield, Ill., 1946, Charles C Thomas, Publisher.

UROLOGIC ROENTGENOLOGY. By Miley B. Wesson, M.D., Ex-president of the American Urological Association. Cloth. Price $5.50. Pp. 252, with 258 illustrations. Philadelphia, 1946, Lea & Febiger.

STIMULATION OF HEALING WOUNDS AND ULCER PROCESSES. Symposium edited and supplied with a foreword and summary article by Professor D. I. Goldberg. Cloth. Pp. 266, with 38 illustrations. U.S.S.R., 1946, Tomsk Medical Institute.

OPERATIVE GYNECOLOGY. By Richard W. TeLinde, M.D., Professor of Gynecology, Johns Hopkins University. Cloth. Price $18. Pp. 725, with 318 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

EXTENDED MYOMECTOMY AND OVARIAN CYSTECTOMY. By Victor Bonney, M.S., M.D., B.Sc. London, F.R.C.S. England, Hon. F.R.A.C.S., M.R.C.P. London, Consulting Gynecological and Obstetric Surgeon to the Middlesex Hospital, London. Cloth. Price $6.50. Pp. 282, with 242 illustrations. London, 1946, Paul B. Hoeber, Inc.

THE AMERICAN HOSPITAL. By E. H. L. Corwin, Ph.D., Executive Secretary, Committee on Public Health Relations of The New York Academy of Medicine. Cloth. Price $1.50. Pp. 213, with no illustrations. New York, 1946, Commonwealth Fund.

MEDICAL RESEARCH. A Symposium edited by Austin Smith, M.D. Cloth. Price $5. Pp. 157, with 17 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

FIVE MILLION PATIENTS. By Allen Weir, Freeman, M.D. Cloth. Price $3. Pp. 299, with no illustrations. New York, 1946, Charles Scribner's Sons.

CONDUCTION ANESTHESIA. Edited by James L. Southworth, M.D., and Robert A. Hingson, M.D. Cloth. Price $18. Pp. 981, with 606 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

VICTORY OVER PAIN. By Victor Robinson, M.D. Cloth. Price $3.50. Pp. 338, with 47 illustrations. New York, 1946, Schuman's.

THE CENTENNIAL OF SURGICAL ANESTHESIA. An Annotated Catalogue compiled by John F. Fulton, M.D., and Madeline E. Stanton, A.B. Paper. Price $4. Pp. 102, with 8 illustrations. New York, 1946, Schuman's.

MEMOIR ON SULPHURIC ETHER. By W. T. G. Morton, presented by M. Arago in the autumn of 1847, with a foreward by John F. Fulton, M.D. Paper. Price $1.50. Pp. 24, with no illustrations. New York, 1946, Schuman's.

PRINCIPLES IN ROENTGEN STUDY OF THE CHEST. By William Snow, M.D., Director of Radiology in the Bronx Hospital and Roentgenologist-in-Charge at the Harlem Hospital, New York. Cloth. Price $10. Pp. 414, with 508 illustrations. Springfield, Ill., 1946, Charles C Thomas, Publisher.

MEDICAL USES OF SOAP. Symposium edited by Morris Fishbein, M.D. Cloth. Price $3. Pp. 195, with 41 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

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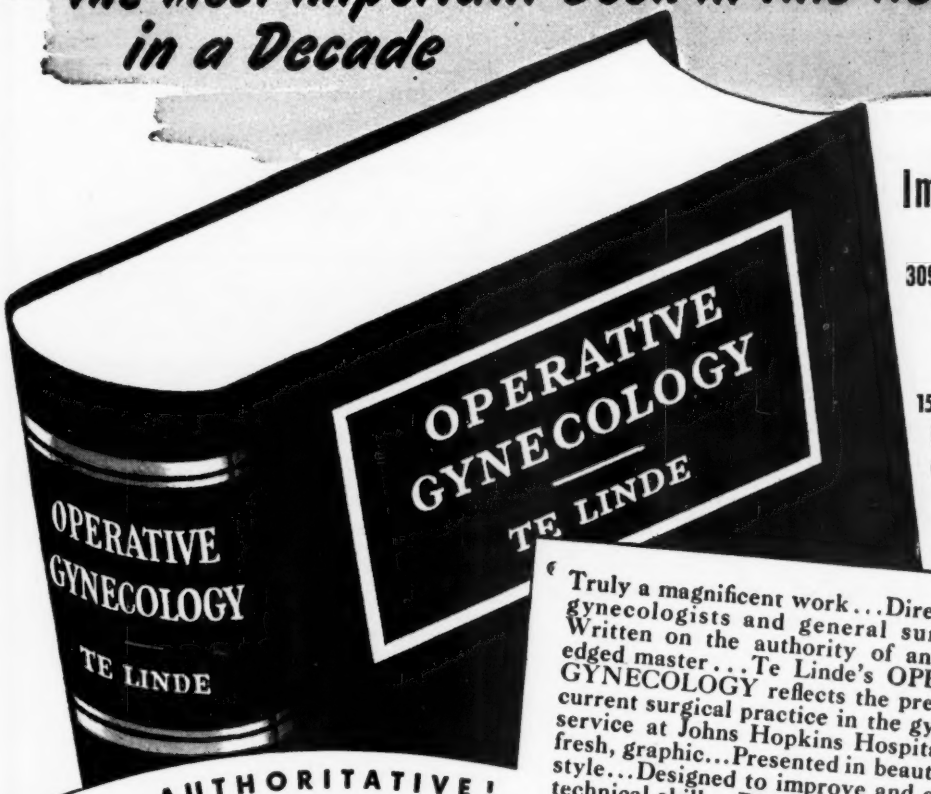


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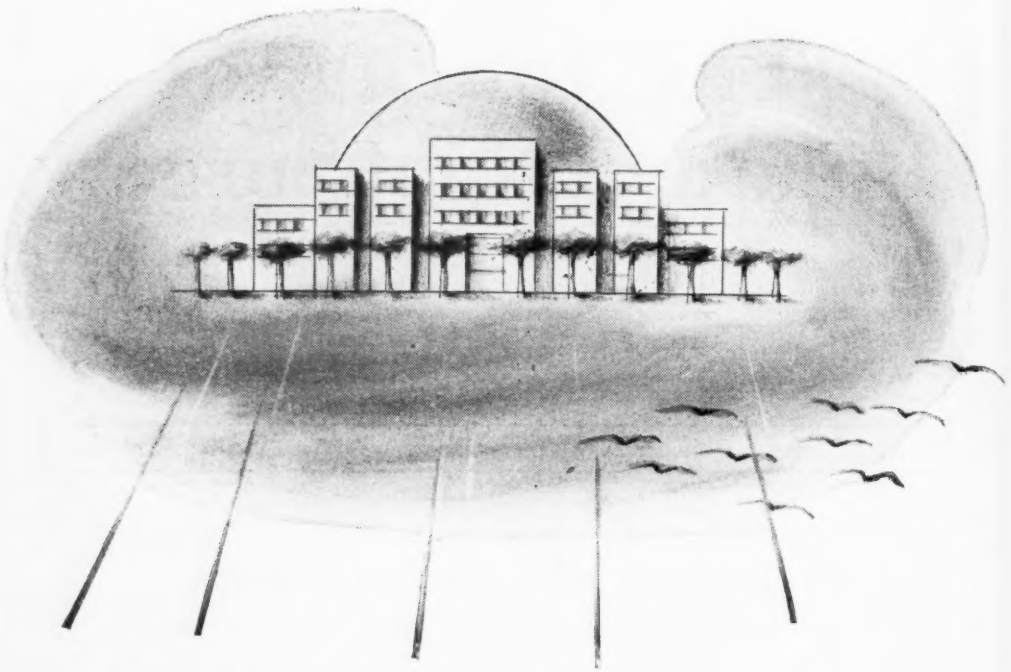

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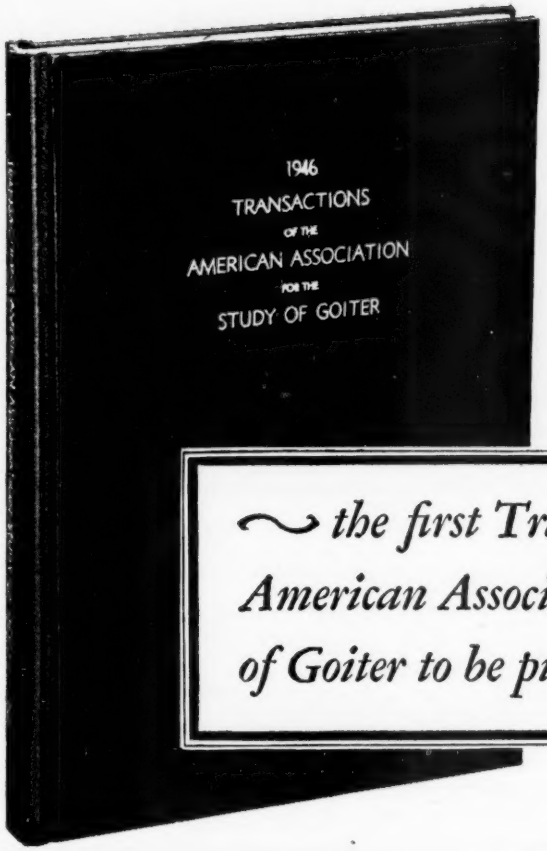


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